A TEXT-BOOK
OF X-RAY DIAGNOSIS
BY BRITISH AUTHORS

"What shadows we are, and what shadows we pursue."

EDMUND BURKE, Sept 9th, 1780

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X-RAY DIAGNOSIS

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IN THREE VOLUMES

Edited by

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The size of the volumes in this reprint has been reduced in order to comply with the regulations now in force prescribing the area of the type surface in relation to the size of the page

The type area is the same as in the first issue and the reduction in size has taken place at the expense of the margin

The Publishers regret this reduction one which somewhat mars the appearance of the volumes and they hope that it will be accepted as a war time necessity When a new edition of the work is called for it will be their endeavour to return to the original format

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PREFACE

The object of the Editors in presenting this text book is to provide within reasonable limits a comprehensive survey of the present position of X ray diagnosis Diagnostic radiology is becoming an increasingly complex specialty, and it is difficult for one person to be equally expert in all its branches The Editors are fortunate therefore in having the help of collaborators, both radiological and clinical, who are distinguished in particular branches of the subject It is hoped that this has made the work the more authoritative and that it will be of value not only to the post graduate student of radiology but also to the clinician In conformity with this design only essential details of technique are included, and the subject of X ray physics is not dealt with

For convenience of reference, the work is published in three volumes, each containing as far as possible subjects of allied interest Thus Vol I deals mainly with the thorax, Vol II with the abdomen, and Vol III with the skeletal and nervous systems

It is not possible, even within the generous limits allowed by the publishers, to illustrate every condition demonstrable by radiology, but the illustrations chosen are, it is hoped, representative, and give due emphasis to the common lesions met with in radiological practice Considerable interchange of material for illustrations has taken place between the various contributors to the book, and the Editors are greatly indebted for the loan of illustrations from other colleagues, detailed acknowledgments of which will be found at the beginning of each volume They are also grateful to Mr Boutall, of Messrs Vaus & Crampton, for the care and attention he has given to the preparation of the blocks, and to Messrs Hazell Watson & Viney for their careful work with the printing

Finally, the Editors desire to express their sincere thanks to the publishers, and in particular Mr H L Jackson and Mr F Boothby, for their co operation and advice, without which this book could not have come into being

February 1938

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VOLUME II

PART ONE

ALIMENTARY TRACT

BY

S. COCHRANE SHANKS, M.D., F.R.C.P., F.F.R.

A TEXT-BOOK OF X-RAY DIAGNOSIS

PART ONE

SECTION I

SALIVARY GLANDS, PHARYNX, AND ŒSOPHAGUS

CHAPTER I

THE SALIVARY GLANDS

ANATOMY

The Parotid Gland lies in the side of the face immediately below and in front of the ear. Its relations are as follows: Above, it is bounded by the zygoma; behind it lies the sterno mastoid muscle; in front is the ascending ramus of the mandible. It extends below to a line drawn between the tip of the mastoid process to the angle of the jaw. It sends a deep extension downwards to the pharyngeal wall, but most of the gland is superficial.

The duct of the parotid, Stenson's duct, is about $2\frac{1}{2}$ inches in length. It begins by *the fusion of numerous branches in the anterior portion* of the gland, and runs forward on the masseter muscle. At the anterior border of that muscle it bends sharply inwards, pierces the buccinator muscle, and runs forward under the buccal mucosa to open in the mouth opposite the second molar of the upper jaw. According to *Hamilton Bailey*, Stenson's duct is devoid of musculature. A small lobe, the socia parotidis, extends forwards along the posterior part of the duct.

The Submaxillary Gland lies in the submaxillary triangle in the neck. From a radiographic point of view its important relationship is that to the mandible. The upper half of the gland lies under the mandible, against the submaxillary fossa *on the inner surface of that bone. This point is of importance when looking for a submaxillary calculus in a lateral radiogram.* The submaxillary duct, Wharton's duct, begins by *the fusion of several small ducts* at the upper border of the gland. It is about 2 inches in length, and runs forwards, inwards and upwards to open in the floor of the mouth, in a papilla on the plica sublingualis close to the frænum linguæ. Wharton's duct is also

devoid of muscular tissue Its wall is much thinner than that of Stenson s duct

The Sublingual Gland is small and almond shaped It lies under the mucosa of the floor of the mouth Its anterior relationship is the inner surface of the mandible close to the symphysis Its excretory ducts, the ducts of Rivinus, are from eight to twenty in number The majority of them open on the crest of the plica sublingualis One or two join Wharton's duct This last fact is of importance in sialography of the submaxillary gland The cannula may pass into one of these ducts and the injection fail to reach the intended gland

RADIOGRAPHIC TECHNIQUE

The salivary glands may be examined in a plain radiogram or after the injection of a contrast medium The usefulness of the former method is limited to the demonstration of salivary calculi For the demonstration of any other lesion of the salivary apparatus contrast medium radiography—sialography—is required

The plain radiograms necessary depend on the site of the calculus If it be in the parotid stereoscopic lateral radiograms should be taken centring over the gland with the neck somewhat extended and the mouth half open

For the demonstration of submaxillary calculi stereoscopic lateral radiograms should be taken and also a submental view with an intra-oral cassette, or an occlusal dental film

The stereoscopic lateral views should be taken with the mouth closed and the head extended The central ray should be directed towards the suspected gland with a *slight* cephalic inclination just enough to avoid superimposition of the two horizontal rami of the mandible For the intra-oral view the so called occlusal dental film of size 2¼ by 3 inches should be used either plain or in an intra-oral intensifying screen cassette The cassette or film is introduced as far into the mouth as possible the teeth gently closed on it and the central ray directed underneath the chin as nearly normal to the plane of the cassette as possible

The technique for the submaxillary gland also serves for the sublingual In the case of the sublingual the intra-oral film is of particular importance

SIALOGRAPHY

Sialography may be defined as the radiographic demonstration of the salivary ducts and alveoli by means of the injection of a radiographic contrast medium

Historical—*Barsony* was the first to publish a case using potassium iodide Several cases were then reported with lipiodol as the contrast medium, and in 1931 *R T Payne* gave a full account of the technique and indications and described four cases In 1933 *Pyrah* described the sialographic picture in four cases of chronic parotitis

Indications—Sialography is of value in the investigation of abnormalities in the ducts salivary calculus fistula sialitis and tumours of the parotid and

submaxillary glands It cannot be applied to the sublingual, for want of a large enough duct

Technique.—Provided all manipulations are gentle, sialography is a safe procedure So far no untoward after effects have been noted, and there is reason to believe that the introduction of lipiodol into the glands in cases of chronic sialitis has a therapeutic effect

Apparatus—*The essential piece of apparatus is the glass cannula* This is easily made from 3 mm glass tubing One end of this is drawn out to a fine point 1 mm or less in diameter The end should be flamed to round it off, if the flaming process be overdone, the lumen is apt to be sealed off This may be prevented by blowing through the tube during the heating process A series of varying sizes should be at hand The glass cannula is connected to an ordinary 5 c c record syringe by a flexible rubber connection The rubber connector piece of a ureteric catheter is usually efficient, but the force needed to join the cannula and the record syringe into the connector piece may disturb the cannula in the duct and it is better to use a rubber tube attached to a bayonet catch syringe nozzle The cannula and tube must be filled with lipiodol before insertion, to prevent air being driven into the duct

Payne recommends the use of an angled glass fountain pen filler, the point drawn out into a suitable cannula This works very satisfactorily except in cases which require rather more pressure than can be exerted by the rubber bulb of the filler

As an alternative to a glass cannula an olive tipped silver cannula may be used *This is made with a standard needle butt for direct attachment to a syringe It is essential that the olivary tip be properly rounded for fear of damaging the delicate duct with a sharp or rough point This can easily be verified under a microscope*

Preparation of the Patient—*A mild antiseptic mouth wash should be used immediately before the injection In order to bring the duct orifice into clear view*, the gland should be massaged Failing this, the patient should suck a slice of lemon

The Injection—This may be given either with the patient sitting up or lying down on the X ray couch Sitting up is the more convenient The cannula, filled with lipiodol, should be introduced for about ½ inch down the duct, and the injection of ¼ to ½ c c slowly given It may take a minute to fill the gland satisfactorily Pain in the gland is an index that enough has been given After the injection has been completed, the patient may keep the cannula in situ in the duct by closing the lips gently This procedure marks the site of the orifice, and enables a further injection to be made if the first has not filled the ducts and alveoli completely

The Radiograms—Lateral stereoscopic radiograms should be taken in the positions described under plain radiography Stereoscopy gives so much

clearer an idea of the disposition of the ducts and alveoli that a single radiogram should not be considered an adequate investigation

In cases where the interpretation of the sialogram is doubtful a control investigation of the sound side may be of help The radiograms should be taken *as expeditiously as possible* The lipiodol tends to percolate into the alveoli after ten to twenty minutes and to blur any radiograms taken after too long an interval The hazy shadows of the minute alveoli obscure the outlines of the fine ducts

SALIVARY CALCULI

The presence of a calculus is the only abnormality which can be demonstrated by plain radiography and a confident opinion negative or positive

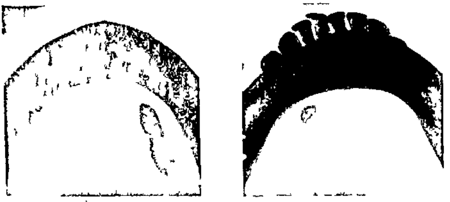


Fig 1 Fig 2

Two cases of submaxillary duct calculus shown by an intra-oral film

can be given radiologically because of the density of the calculi They are composed of calcium carbonate and calcium phosphate often in alternate layers and cast a relatively dense shadow All but the very smallest should be detectable in a satisfactory radiogram

The submaxillary gland is much the commonest site of calculi According to *Wakeley* the relative frequency in the three glands is as follows

Submaxillary 63 per cent
Parotid 21 per cent
Sublingual 16 per cent

Calculi may occur either in the duct or in the gland The duct calculi are oval or elongated rather rough in surface lie with the long axis in that of the duct and may show lamination (Figs 1 and 2) They may attain the size of a date stone and more than one may be present

The gland calculi tend to be round in contour may be single or multiple and may reach the size of a green pea (Fig 3)

Although the above characteristics and the position of the calculus relative to the bony landmarks may be some indication of its site, sialography gives accurate information, and in addition will indicate the degree of the essential ætiological factor, the associated sialitis. This additional method should therefore be used in all cases of salivary calculus.

FIG. 3.—Large submaxillary calculus.

Differential Diagnosis.—Two structures may be mistaken for a salivary calculus: a calcified gland, and a localised area of bone sclerosis in the mandible. The latter especially may simulate a calculus in a plain lateral view, but stereoscopy and the occlusal film show its true nature.

FIG. 4.—Normal parotid sialogram. Note the double socia parotidis—an anatomical variation.

THE NORMAL SIALOGRAM

In the parotid sialogram the duct is narrowest at the buccal orifice and rapidly widens out to a calibre of about a millimetre. The bend which it takes as it dips through the buccinator muscle is usually visible. On tracing the duct back to the gland a large branch duct forks upward—the duct of the socia parotidis. The ducts of the main gland are many and tend to join the main duct at right angles giving an appearance like a double comb. These subsidiary ducts break up into fine twigs. No terminal gemmules or dilatations are visible. In the submaxillary sialogram the duct lumen may be larger in bore—up to 2 mm. as a result of its thin distensible wall.

Fig. 5.—Chronic sialitis of the parotid gland. Sialogram showing terminal dilatations of the ducts or sialectasis.

Fig. 6.—Sialogram of a mixed tumour of the parotid. Note the filling defect of the upper part of the gland.

The secondary ductules are less regular than in the parotid but otherwise present a similar appearance (Fig. 4).

Salivary Fistulæ.—*The internal fistulæ* are of no importance since they cause the patient no inconvenience.

Of the external fistulæ the gland fistula usually heals rapidly under simple treatment and the only one of radiographic interest is the fistula of Stenson's duct.

It is desirable to demonstrate with what part of the duct the fistula communicates since the nearer to the gland it is the more difficult the treatment

The fistulous opening on the cheek should be marked with a fine wire ring and the duct injected with lipiodol through the anatomical ostium If the duct distal to the fistula be stenosed, it may be necessary to make the injection through the sinus *An attempt should be made in each case to fill the whole* duct up to the gland

Chronic Sialitis —It is in this class of case that sialography finds its greatest sphere of usefulness The radiographic appearances afford evidence not only to diagnosis, but also the degree of the inflammatory process and consequently the prognosis Changes may be evident both in the duct and in the gland

The duct changes consist in dilatation, with, possibly, localised constrictions The thin-walled Wharton's duct is more prone to dilatation than Stenson's The gland changes consist in progressively increasing dilatation of the duct terminations *Commencing in an early case as minute buds the size of a pin-head or less,* they gradually enlarge to a size of 1–3 mm in diameter in long-standing cases To this change the term sialectasis has been applied The condition shows a close radiographic similarity to bronchiectasis (Fig 5)

Of the two changes, the terminal dilatation—sialectasis—is the earlier, and the essential The duct dilatation occurs less frequently The cause of the sialectasis is not proved, but a plausible explanation is chronic back pressure from plugging of the duct with tenacious mucus or muco pus Indeed, the sticky nature of the resting duct contents may be seen clearly in performing a sialography On giving lemon to suck, instead of a rapid and free discharge of watery saliva, there may be seen a delayed, sluggish pouting of the orifice by the extrusion of a bead of thick mucus

Salivary Gland Tumours —Although the nature of these tumours—i e their salivary gland origin—is usually evident clinically, if there be any doubt, a sialogram may be of help The parotid gland tumours lend themselves best to this form of investigation A filling defect is produced by the tumour A slow-growing benign tumour tends to push the ductules on one side, and a deformity of this type may be evident A rapidly growing invasive neoplasm destroys the ductules in its path, and in this case the sialogram shows an absence of filling of these ducts (Fig 6)

Mikulicz's Disease —According to *Payne*, the sialographic appearances are normal in this condition

CHAPTER II

THE NORMAL PHARYNX AND ŒSOPHAGUS

ANATOMY

As *the pharynx* is open to direct inspection X ray examination is rarely called for except in cases of pharyngeal diverticulum and post cricoid carcinoma

In a lateral view all three portions of the pharynx are visible by virtue of the air contained therein This air space is continuous in the naso pharynx with the nasal cavities In the oro pharynx it is bounded in front by the tongue if the mouth be closed In the laryngo pharynx it turns forwards and narrows into the laryngeal vestibule and can be traced down into the trachea The lower part of the laryngo pharynx below the laryngeal opening is a potential space only in the resting subject The posterior boundary of the *pharyngeal air space follows the curve of the cervical spine and any preverte* bral swelling such as a retropharyngeal abscess is clearly visible Anterior to the pharynx are two landmarks—the hyoid bone and below it the thyroid cartilages usually calcified in adults and so visible Frequently the epi glottic shadow is visible separated from the base of the tongue by the vallecula

The œsophagus a muscular tube is about 9 to 10 inches in length It begins at the upper border of the cricoid cartilage at the level of the 6th cervical vertebra and descends in front of the vertebral column passes through the œsophageal opening of the diaphragm to end at the cardiac orifice of the stomach opposite the eleventh dorsal vertebra Its general direction is vertical and median but it curves slightly to the left at the root of the neck becomes median at the level of the fifth dorsal vertebra and again deviates to the left as it reaches the diaphragm It also presents antero posterior curves corresponding to those of the cervico dorsal spine

Certain of its relationships are of radiographic importance In the thorax *it passes behind the aortic arch separated from it by the trachea then descends* in the posterior mediastinum at first to the right of the descending aorta then in front and slightly to the left of it In front the left bronchus crosses it and below *this it is in relationship to the left auricle*

In the abdomen it runs in the œsophageal groove on the posterior surface of the liver This portion is short ½ to 1 inch in length

The lumen varies slightly It is narrowest at its two sphincters the cricoid and cardiac and is slightly narrower opposite the aortic arch It presents a slight bulb or dilatation immediately above the diaphragm

TECHNIQUE OF INVESTIGATION

The essentials of the X ray examination of the œsophagus are to observe the passage of an opaque medium along its lumen under the fluoroscopic screen, and to take radiograms thereof as a permanent record

For routine examinations the patient should if possible be examined first *in the erect position* The chest should first be screened to exclude gross abnormality, and the patient then turned into the first (right) oblique position This brings the whole of the œsophagus into clear view as it descends in the posterior mediastinal space On a bolus of opaque cream being swallowed, its course is observed from the mouth to the cardiac orifice If a suspected lesion be not demonstrated by a barium cream, a barium paste or biscuit may show it

Following the screen examination, at least two radiograms of the whole extent of the œsophagus should be taken, each immediately after swallowing a mouthful of the cream Frequently more are necessary to determine the constancy of an abnormality The exposures should be as brief as possible, in order to avoid transmitted cardiac movement

In cases of gross obstruction further radiograms at intervals may be advisable, and at times the left oblique view may be of value

Although the above procedure will show the majority of œsophageal lesions satisfactorily, it is often necessary to examine the patient in the horizontal position, or the Trendelenburg in order to demonstrate the upper and lower limits of the lesion Again postero anterior, lateral and/or left oblique views are at times necessary to demonstrate the exact site of a pharyngeal pouch A postero anterior view similarly demonstrates the lower end of the œsophagus in gross œsophagectasia from cardiospasm

The Double Swallow Method —This is of use in showing the upper and lower limits of an œsophageal lesion especially carcinoma The patient swallows some ounces of a thin barium cream After this has passed into the stomach he assumes the right oblique Trendelenburg position If the patient in this position swallows another mouthful, the cardia relaxes and allows regurgitation into the œsophagus A bolus of thick cream is then swallowed, to outline the upper limit of the lesion The method is not always successful as regurgitation may not take place but even if there is no reflux the normal transit is slower, and more likely to outline the lower limit of a stenosis In cases of carcinoma in which it is proposed to insert a *Souttar's* or other tube it is of particular value, and should be tried if simpler measures have failed to demonstrate the full extent of the narrowing

The Opaque Media —The particular formula used for the *barium* cream is unimportant, provided it contains a sufficiency of barium and is of the proper consistency, that of a thick uniform cream If the œsophagus only requires investigation any excipient may be used cereal, Benger's, mucilage If, however, as is frequently the case, the stomach also is to be studied, the cream

should be suitable also for that organ and it is the writer s custom to use a cream the same as for the stomach This can be made thicker if found on preliminary examination to be necessary, by the addition of barium sulphate powder

The formula used by the writer is as follows

Barium Sulphate	℥ 10
Saccharine	grs 2
Gum Tragacanth	grs 60
Essence of Raspberry	♏ 45
Aqua ad	θ 1

A satisfactory paste is formed by mixing equal parts of the above and *powdered barium sulphate*

Barium Biscuit —Several satisfactory brands are on the market These are of use *when it is desired to excite an intermittent spasm of the œsophagus* The biscuit should be swallowed with as little mastication as possible but it should be borne in mind that if swallowed too dry it may stick in a normal œsophagus for quite an appreciable time

The barium pellet usually in the form of a barium glycerine suppository is still more erratic in its behaviour It may remain immobile in the normal œsophagus for many seconds or even minutes and in a case of obstruction may be arrested some distance above the site of the lesion In such a case a mouthful of water will cause its descent to the actual site of obstruction

Barium Wool —This consists of small pledgets of wool soaked in barium cream and is of value in showing the site of an impacted fishbone or other transparent pointed foreign body in the œsophagus

Barium cream followed by water may be of value in certain cases of impacted foreign body *(q v)*

An important point in technique is that if obstruction be present a thin *cream should always be used first The use in the first instance of a paste or* biscuit is liable to cause the patient some distress if the stenosis be marked

THE PHYSIOLOGY OF SWALLOWING

A F Barclay has made an admirable and very complete X ray study of the process of deglutition and the description below is based on the very full account he has recently published of his research

He studied fluoroscopically and by serial radiograms the act of deglutition in a large number of normal subjects

Briefly the sequence of events as he describes them is as follows

(1) THE LARYNX rises

(2) THE PHARYNGEAL SPACE becomes obliterated for a fraction of a second immediately before the food is propelled backwards over the tongue

(3) THE PHARYNGEAL SPACE then opens to receive the bolus which is rapidly *shot into it and down into the upper third of the œsophagus* The

food is seen by the fluoroscope to pass down so quickly as to suggest that it is sucked down

During the act of swallowing, all three pharyngeal openings, nasal, oral, and laryngeal, are firmly closed

(4) THE RÔLE OF THE EPIGLOTTIS is a curious one It was formerly held that the epiglottis acted as a cover to the laryngeal vestibule Nothing of this nature takes place and apparently the chief function of the epiglottis is to form, with the vallecula in front of it, a trap for saliva passing down the back of the tongue between the acts of deglutition

During deglutition the epiglottis is pressed against the posterior pharyngeal wall in the closed phase In the open phase, when the bolus is being shot back into the pharynx, the epiglottis projects upwards, free of both anterior and posterior pharyngeal walls, "*like a rock projecting upwards under a waterfall*" as *Barclay* puts it Normally food passes over it into the pharynx, but occasionally a small portion is trapped by it and lodges in the vallecula, thence to be dislodged by a second act of swallowing

(5) THE CLOSURE OF THE NASO PHARYNX results from the combined action of the superior constrictor of the pharynx and elevation of the palate

(6) THE TONGUE closes the oro pharyngeal opening

(7) THE CLOSURE OF THE LARYNGEAL ORIFICE is a complicated process Firstly, the laryngeal vestibule is obliterated as far as the false vocal cords by a protrusion of the base of the tongue backwards and downwards between the hyoid bone in front and the epiglottidean base behind The hyoid rises and appears to "swallow" the base of the tongue Secondly the anterior wall of the laryngo pharynx rises behind and on either side of the laryngeal vestibule and further occludes it The muscular action involved in this last process is obscure but the anterior pharyngeal wall below the laryngeal vestibule is very loosely attached, and this radiological observation is certainly possible anatomically

A final paradoxical observation in Barclay's research is that the vestibule of the larynx appears to open up as the hyoid bone descends and just as the food is about to pass down behind it

The above complicated act of deglutition is continued into the upper third of the œsophagus Below that level the peristaltic action of the œsophagus takes charge In other words, the chain of reflex action includes the upper part of the œsophagus

The rapidity of the transit of the food in this reflex was investigated by *Barclay* in collaboration with *Anrep*, and they came to the conclusion that the food really was sucked down and that there is a negative pressure in the lower pharynx and upper œsophagus They found, on passing a rubber catheter into the upper œsophagus and connecting it to a monometer, a negative pressure of 16–18 cm water when bread was swallowed

In the Lower Two-thirds of the œsophagus the food is impelled downwards

by a rapid peristaltic wave This wave is not deep and does not segment the bolus It does not produce an occlusive peristaltic ring and if obstruction be present below some of a fluid medium is squirted up through the ring to simulate reverse peristalsis True reverse peristalsis does not appear to occur in the œsophagus

FIG —Normal œsophagus in the right anterior oblique view

The action of the cardiac sphincter is variable in the normal subject Sometimes it appears to act as a patulous canal and at other times as a sphincter responding to the inhibitory impulse of a peristaltic wave in *the œsophagus*

NORMAL X-RAY APPEARANCES

In the erect position the barium cream *can be seen to pass smoothly* down the œsophagus in a rapid peristaltic wave In the right oblique view its course is down the posterior mediastinum with the dorsal spine behind and the aorta and heart in front It follows the curve of the spine separated from it by about an inch The aortic arch indents it slightly—the aortic impression

In addition to the aortic impression there are described three other slighter indentations of the œsophagus caused from above downwards by the left main bronchus the left auricle and the lower end of the thoracic aorta These are of *importance in cardio vascular disease* and are considered in detail in that section (Fig 7)

In both the first oblique and postero anterior views all four impressions are concave to the left

The œsophageal lumen as visualised by the opaque cream varies somewhat at different levels The aortic impression causes an apparent narrowing From this point the lumen becomes wider down to the diaphragm Just above this it narrows and finally tapers towards the cardia

The rate of transit through the œsophagus depends, in the normal subject, on the position of the patient and the consistency of the contrast medium. In the erect position, with the cream above described, the average time is two to three seconds. This time is lengthened with thicker media and with a dry biscuit which has been swallowed with little ensalivation the time may be thirty seconds or even a minute or two.

The supine posture increases the time of transit with the standard cream up to four to six seconds but not that of the thicker media.

Frequently a small residue remains in the lower œsophagus, after the swallowing of a bolus of the cream. It shows as a thin streak or series of longitudinal striæ above the level of the diaphragm, which gradually disappear after a short interval. When a quantity of thin cream is swallowed quickly the lower part of the œsophagus may fill up to a considerable extent, e.g. the whole of the lower third, and then empty suddenly into the stomach.

In the postero anterior view most of the œsophagus is partly obscured by the mediastinal, cardiac, and spinal shadows. This view is of use in examining the last few inches of the œsophagus, and in the investigation of diverticula and cardiospasm.

CHAPTER III

DISEASES OF THE PHARYNX AND ŒSOPHAGUS

DYSPHAGIA

THE vast majority of cases referred for œsophageal examination are so referred on account of dysphagia and X ray investigation affords the most accurate and the safest method of determining the presence site and type of a lesion causing that symptom Before considering the various types of œsophageal obstruction certain general considerations are worthy of note The X ray appearances under the fluorescent screen vary considerably according to the stage and site of the obstruction

Stages of Œsophageal Obstruction

FIRST STAGE of Simple Dysphagia —In this there is no pain little dilatation and little obstruction Fluids may pass and only thicker media cause any discomfort

SECOND STAGE that of painful dysphagia The patient beginning to lose flesh definite delay in the œsophagus with powerful peristalsis and reflux of the medium

THIRD STAGE the stage of atonic dilatation and starvation of the patient The œsophagus gives up the struggle and acts as a reservoir Barium may remain in it for hours

Variations in the Picture according to the Site of the Obstruction

IN OBSTRUCTION IN THE UPPER THIRD the dysphagia is marked The act of deglutition itself is difficult the barium is rapidly regurgitated the epiglottic vallecula pyriform fossæ and larynx tend to be coated with barium and some of the medium frequently passes into the trachea accompanied by coughing and distress on the part of the patient There is little or no dilatation in the œsophagus proximal to the obstruction as little of the contrast medium is retained therein

IN THE MIDDLE THIRD there is less difficulty in deglutition less tendency to distressing regurgitation and more dilatation of the œsophagus

IN THE LOWER THIRD the œsophageal dilatation is at its maximum, discomfort at its minimum and retention of the opaque cream above the point of obstruction is considerable

At any given point the degree of dilatation varies according to the type of lesion Thus it is greater in benign than in carcinomatous stenosis and

reaches its maximum in spastic conditions, cardiospasm being the extreme example It also varies directly with the degree of narrowing

PHARYNGEAL DYSPHAGIA

In a number of conditions in the pharynx there may be a considerable dysphagia quite apart from any obstruction in the œsophagus Amongst the causes of this are bulbar palsy, pharyngeal pouch extrinsic pressure on the pharynx from tumour or prevertebral abscess hypopharyngeal or post cricoid carcinoma, acute tonsillitis or other type of " sore throat " Plummer Vinson syndrome or even simple nervousness

The X ray appearances on swallowing a mouthful of barium are the same as those of high œsophageal obstruction (or more exaggerated in degree), except that as soon as the barium reaches the œsophagus proper it passes down normally In addition, some of the above causal lesions show special radiographic characteristics which render them recognisable

Extrinsic Pressure from prevertebral abscess or tumour is visible in a true lateral picture of the neck by encroachment on the pharyngeal air space In the former, the forward bulge of the posterior pharyngeal wall is readily recognisable

Pharyngeal Diverticulum—The rare *congenital post tonsillar diverticula* arising in connection with the second branchial cleft are not susceptible to X ray demonstration and require no consideration

The deep pharyngeal pressure diverticulum is a much commoner lesion and is clearly demonstrated by X ray examination These diverticula, still commonly referred to as œsophageal occur on the posterior wall of the pharynx, about 1 cm above the upper end of the œsophagus at the pharyngeal dimple This dimple, median in site, marks a small gap between the oblique and transverse fibres of the inferior constrictor of the pharynx, and the pouch commences as a herniation of the mucosa through that gap The commonly accepted view of the mechanism of development of the pouch is that repeated forcing of food into this pocket during the act of swallowing gradually enlarges this pouch downwards until a diverticulum of large dimensions may result The opening of the pouch is median, transverse and slit like and may reach an inch in length This theory is at variance with Barclay s theory of the act of deglutition, described above, and he suggests that adhesions of the posterior pharyngeal wall to the prevertebral fascia behind may be the cause The pouch, when empty is collapsed in the coronal plane and as a rule lies in the midline but as it enlarges may deviate somewhat to either side, more commonly to the left

X RAY APPEARANCES—In the right or left oblique position the contrast medium is seen to pass down into a rounded flask shaped pouch, and then to spill over anteriorly down the œsophagus Frequently the barium cream passes into both simultaneously In early cases without marked symptoms,

in which the pouch is small it may retain a residue or may remain quite full without discomfort and empty very gradually A pharyngeal pouch does not as a rule cause œsophageal obstruction by extrinsic pressure Even when large the dysphagia is caused by overflow emptying of the filled pouch into the pharynx resulting in hawking and choking until it is partly emptied A pool may be left for some time in the fundus of the sac Characteristically the barium filled pouch shows a horizontal fluid level and a successful radio

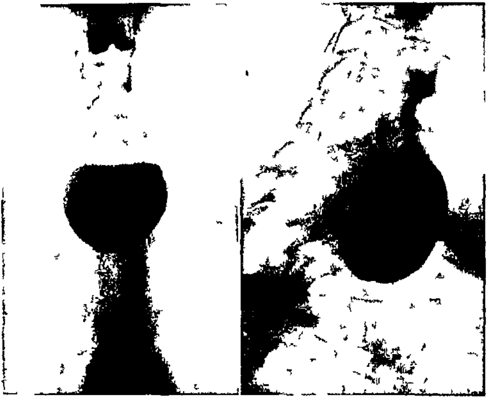


FIG 8—Two cases of pharyngeal pouch seen in the postero-anterior and right oblique views respectively

gram of the condition should show a stream of barium cream passing down the œsophagus in front of the shadow of the pouch (Fig 8)

The size of the pouch may vary from 1 10 cm across and one of the latter dimensions may have a capacity of as much as 4 5 oz The contour of the barium filled sac is regular and rounded unless food remnants are already present therein The outline of the sac in the postero anterior view is occasionally bilocular taking the shape of an inverted conventional heart Carcinoma may develop in a pouch and be visible as a filling defect in the barium shadow

This view is of value in determining to which side a diverticulum deviates if at all, a point of importance in case of operation

Traction Diverticula are very rare They result from the traction on the œsophagus from contracting extrinsic scar tissue According to *R S Paterson* (Fig 9) they are usually situated on the right anterior wall of the œsophagus and are horizontally disposed They are therefore best viewed in the left oblique position They fill better with the patient lying down The great majority of them are symptomless but *Paterson* records that dysphagia regurgitation and substernal pain have occurred from impaction of food in the pouch Those which are epiphrenic and epicardiac in site may be associated with dysphagia and œsophagectasia (*Schin*)

FIG 9.—Congenital partial thoracic stomach with short œsophagus and a small traction diverticulum of the œsophagus visible only in the left oblique supine view

Hypopharyngeal and Post cricoid Carcinoma — A true lateral position should be used in investigating this condition The dysphagia is marked and the sequence of events so rapid as seen under the fluoroscope after an opaque swallow that little can be seen beyond that the opaque medium does not pass smoothly into the œsophagus Regurgitation of some of the barium is common usually by a coughing reflex The latter is induced by escape of the cream into the larynx A radiogram taken after an

opaque bolus has been swallowed will show irregular fragments of barium entangled in the growth, and probably some coating with barium of the vallecula, pyriform fossæ and even larynx and trachea

FIG 10 —Early post cricoid carcinoma causing slight œsophageal obstruction and pressing on the posterior wall of the trachea

A lateral radiogram, taken without any opaque swallow sometimes gives quite a characteristic picture The tumour projecting into the hypopharynx encroaches on the air space and its outline is thus shown up in relief This applies particularly to a tumour growing from the posterior wall (Fig 10)

Plummer-Vinson Syndrome. — Dysphagia is a common symptom in this condition, resulting from atrophy of the buccal and pharyngeal mucosa and spasm or achalasia of the crico pharyngeal sphincter The radiographic picture is merely that of pharyngeal dysphagia, and the diagnosis must rest on the clinical and hæmatological features

CONGENITAL MALFORMATIONS OF THE ŒSOPHAGUS

These are very rare and are usually incompatible with life According to *Whipham and Fagge* the following have been recorded

Congenital absence

Congenital atresia, with or without tracheo œsophageal fistula

Congenital stenosis of the lower end

Bifurcation, uniting at the lower end

The symptomatology of the obstructive lesions is very typical inability to retain fluids regurgitation of fluid through the nose attacks of dyspnœa cough and cyanosis on feeding and broncho pneumonia dehydration wasting and death in a week or so

In cases where there is a tracheo œsophageal fistula the upper œsophagus ends below as a blind pouch and the lower œsophagus communicates above with the trachea usually at the bifurcation Gas therefore reaches the stomach and intestine via the trachea and lower gullet The radiographic diagnosis rests on the demonstration of a barium filled blind upper œsophageal pouch and a stomach distended with gas *Mathieu and Goldsmith* have recorded two such cases

FOREIGN BODIES IN THE ŒSOPHAGUS

These may be of many varieties but fall into two types opaque and transparent The technique for each type is different

Whether a foreign body becomes impacted in the gullet or not depends on its size and shape Small rounded bodies pass larger ones and most irregular or spiked ones even though small usually impact The impaction of small irregular bodies depends on their causing trauma to the œsophageal mucosa with resultant spasm

Opaque Foreign Bodies —The variety of these which have been recorded is legion Coins small tooth plates pins safety pins needles portions of children s toys and dense meat bones are all of common occurrence (Fig 11) The commonest site of impaction is a little above the aortic arch and next at the lower end of the œsophagus Impacted flat bodies e g coins lie in the coronal planes In the trachea they impact in the sagittal plane a distinguishing feature Small pointed bodies such as pins or needles may impact at any site They often pass into the stomach and their impaction depends on penetration of the point into the œsophageal wall They form the most dangerous type because of this liability The writer met with a case in which a Gillette razor blade became impacted and which resulted in a fatal mediastinitis

The large opaque foreign bodies are easily detected by X ray examination both under the screen and in a radiogram A series of radiograms must however be made in every case in which it is suspected that an opaque foreign body has been swallowed beginning with the œsophagus If none is found therein the whole abdomen should be examined in case the object has escaped through the cardia It is wise also to make sure by radiograms that the body is not in the bronchial tree

Calcification in the cricoid or arytenoid cartilages may simulate an impacted bone A distinguishing point is that a barium swallow passes behind them but the arytenoids are so close to the pharyngeal lumen that differentiation may be impossible without pharyngoscopy

Frequently small bodies such as pins cannot be seen on screen examination They are always visible in radiograms of first quality

After an opaque foreign body has been localised in the œsophagus a

(a) The bone in the gullet (b) Barium wool pledget impaled on the bone

(c) The extracted bone Life size

FIG 11 —Pheasant bone impacted in the œsophagus

mouthful of opaque cream may be given to determine the degree of spasm or obstruction

Transparent Foreign Bodies —The common ones are small or thin meat and fish bones and vulcanite fragments of tooth plates

As the foreign body is not directly demonstrable in a radiogram its presence

impacted in the œsophagus suggested by the symptomatology, must be shown by other means

(1) A *barium cream* may demonstrate an obstruction at the site of the impaction either from the foreign body itself if it be large or from spasm if ulceration has taken place Frequently however the cream is seen to pass down without any obstruction when the foreign body is small such as a fish bone

(2) In such a case a *small pledget of wool* soaked in barium cream should be swallowed by the patient and its course down the œsophagus observed fluoroscopically *It is given in the hope that it may become entangled in the projections of the foreign body* and a clue be afforded to the site of the latter This test is not very certain as in the normal subject the passage of the pledget down the œsophagus may be slow and erratic A small chaser of opaque cream may help it down to the impacted body but frequently washes it down past it Some laryngologists dislike this method as it may obscure the foreign body

(3) A method *Twining recommends is to give alternate drinks of barium cream and water* The latter clears a normal œsophagus but may not if a foreign body is impacted The value of the test is enhanced if repetition several times always gives the same result

CARCINOMA OF THE ŒSOPHAGUS

Carcinoma is far and away the commonest intrinsic lesion found in the œsophagus It probably accounts for at least 90 per cent of all cases of dysphagia examined in an X ray department

Types

(1) Squamous celled the common variety
(2) Cylindrical celled arising from the mucosal glands
(3) Colloid
(4) Diffuse scirrhous

The two latter are rare

Morbid Anatomy—At first limited to the mucosa the growth tends t become annular *in distribution and thus to cause stenosis* Small cauliflowe excrescences and ulceration combine to produce a narrow tortuous channel the appearance of which is so characteristic in a radiogram In time th growth infiltrates the muscular coats of the œsophagus and then the medi astinum *Perforation is not an uncommon sequela most commonly into th* great vessels less commonly into the trachea or bronchus and rarely into th pleura or lung Metastases are uncommon

Sites—Although any portion may be involved the sites of election are th *narrow portions of the œsophagus namely the upper and lower ends and in th* region of the tracheal bifurcation The relative frequency of occurrence a each site is still a matter of dispute but it i probably commonest at or a little

below the tracheal bifurcation and certainly occurs more frequently in the thoracic than in the cervical portion

Radiographic Features —*If as is the rule some narrowing of the*

Fig 12 —Filling defect of an obstructing carcinoma of the upper end of the œsophagus

Fig 13 —Carcinoma of the œsophagus Œsophagoscopy showed a tumour projecting from the right wall of the *œsophagus into its lumen*

œsophageal lumen is present a carcinoma of the gullet presents characteristic features The œsophagus above the growth is to some extent dilated this becoming more marked the tighter the stricture becomes and *the lower the site of the lesion in the œsophagus* The dilated portion may

taper rather abruptly and irregularly into the stenosed passage, or may overhang it

This irregularity is dependent on the precise contour of the upper part of the growth, and if the latter be of the "cauliflower" type, quite a large filling defect may be seen at the lower end of the dilated portion The stenosed passage itself may be from 1 to 4 or 5 inches in length and in the longer varieties it may be necessary to examine in the horizontal position or to use

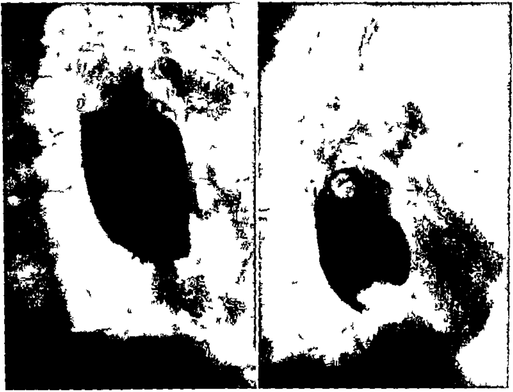


Fig 14 —Two cases of obstructing carcinoma of the lower œsophagus

the double swallow method in order to demonstrate its whole length In cases where the stenosis is shorter, the routine examination in the erect position may serve to show its extent It is of importance to show the stenosis in its entirety if radiotherapy or intubation is contemplated

The most characteristic features of the carcinomatous stricture are its irregularity and the constancy of that irregularity The barium filled lumen typically shows spiky projections and angulations, and the barium stream is frequently broken up into two portions by an intervening protuberant mass of growth, a filling-defect of the stricture itself (Figs 12–14)

These irregularities are constant allowing for variations due to varying amounts of barium contained in the stricture

This constancy is best tested by the superimposition of successive films, each taken after swallowing a bolus of barium emulsion. At least two radiograms should be taken as a routine.

In the rarer scirrhous forms of carcinoma the stenosis is less irregular, and the spiky projections are absent. Difficulty may be experienced in distinguishing between a scirrhous carcinoma and a benign stricture and in many cases it is impossible so to do from the radiographic features alone.

Fig. 15.—Carcinoma of the œsophagus perforating a bronchus. Note barium cream in the bronchial tree.

Perforation of a Carcinoma.—The only varieties of perforation that reach the radiologist are those into the mediastinum, bronchus, or pleura. If into the mediastinum a barium-filled pocket will be seen on swallowing, provided the œdema of the resulting mediastinitis does not compress the œsophagus above the perforation. In cases where the bronchus is perforated the emulsion passes into the bronchi, accompanied by coughing and distress (Fig. 15).

If the pleural cavity be involved the barium cream may flood the pleura, or remain localised by pre-existing adhesions.

Intubation and Radium Therapy.—X-ray examination is often required after the insertion of a Souttar's or Symonds's tube, or the implantation of radon seeds. A radiogram taken in the right oblique view with or without a barium swallow will show if the tube is in the correct position (Fig. 16). Superimposition of the film so taken on that taken of the lesion before intubation is

frequently a help Again such film taken after a barium swallow will show if the lower end of the tube has reached the lower limit of the stenosed passage If the tube has ulcerated through the stenosis and passed down the œsophagus or into the alimentary canal below this will be at once apparent

It is difficult in a plain radiogram to do more than enumerate the radon seeds implanted Their distribution relative to the tumour cannot be arrived at although a stereoscopic pair of radiograms may give a rough idea If a

FIG 16 —Carcinoma of the œsophagus before and after intubation with a Souttar's tube

barium cream be swallowed just before such a pair are taken the stenosed lumen may also be seen stereoscopically and help in the localisation

SIMPLE TUMOURS OF THE ŒSOPHAGUS

These are extremely rare *Palugyay* described the X ray appearances in a case of pedunculated fibroma The features he noted indicate the signs to be expected in these cases The opaque medium is seen on screen examination to be slowed up in a part of the œsophagus which shows no stenosis but which on the contrary may actually appear widened The barium column

may be seen to be divided by a central clear area—the tumour This translucent area may show some marbling from the adhesion of barium to the tumour surface and this process may give an outline of the tumour in relief after the main mass of barium has passed on In contradistinction to carcinoma the walls of the œsophagus in the affected region show no evidence of infiltration and present smooth contours

BENIGN STRICTURE OF THE ŒSOPHAGUS

Ætiology—Simple fibrous stricture of the œsophagus is a late result of ulceration of the mucosa

This ulceration is generally the result of swallowing corrosive fluids or boiling water Occasionally it follows the impaction of a foreign body whilst rarely it is tuberculous or syphilitic

Morbid Anatomy—The formation of the stricture depends entirely on the position extent and degree of the trauma or ulcer which is its cause

In the case of corrosive fluids the injury tends to be localised at the three narrow portions of the œsophagus although the damage may extend over a large portion or the whole of the œsophageal lumen

Types

ANNULAR—This arises from a localised caustic burn or an ulcer from an impacted foreign body It is not common

TUBULAR—This is the common type resulting from an extensive burn or ulceration The muscular coats of the œsophagus are fibrosed and a dense tubular stricture of considerable length results (Fig 17) If the original lesion involved the peri œsophageal tissues fibrous contracture may produce displacement of the œsophagus

In untreated cases these strictures may increase in severity until they become absolute

Radiological Features

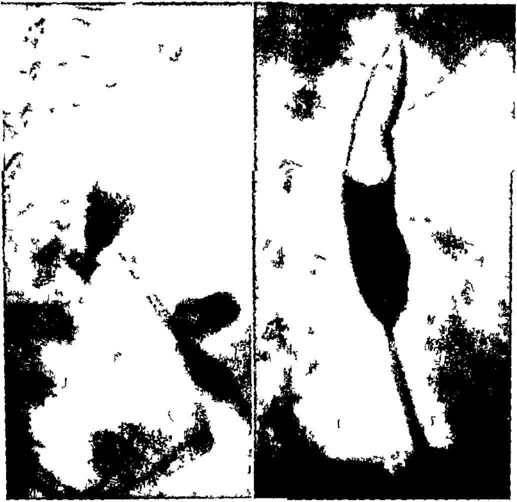
ANNULAR TYPE—The proximal portion of the œsophagus is dilated The degree of dilatation is dependent on the site of the stricture being greater the lower the latter is situated It is commonly held to be greater than in malignant stricture The dilated portion terminates conically below into the stricture with as a rule little irregularity and no supra stenotic filling defects

The stricture itself shows none of the spiky irregularities of the carcinomatous variety These strictures may be multiple

TUBULAR TYPE—Here a considerable portion of the œsophagus may be narrowed The degree of stenosis may vary from point to point along the extent of the stricture but as a rule it lacks the irregularity of the neoplastic type As these strictures usually result from corrosive action the œsophagus

above the actual narrowing tends to become fibrosed from a lesser caustic action and dilatation is therefore absent. Any marked deviation of the œsophageal lumen indicates mediastinal fibrosis and contracture.

The chief diagnostic difficulty in benign stricture is to differentiate it



(a) (b)

FIG 17.—Two cases of benign stricture of the œsophagus. (a) History of dysphagia since childhood, no cause found (? congenital). (b) Tubular stricture three months after swallowing spirits of salts.

radiographically from the scirrhous type of carcinoma. As a rule however the matter is settled by the history of previous trauma.

Treatment.—Fluoroscopy may be of help during the passage of dilating bougies, a procedure which is often difficult.

SPASTIC OBSTRUCTION OF THE ŒSOPHAGUS

The following may occur

(1) Cardiospasm

(2) Spasm from ulceration

(3) Spasm from impaction of foreign bodies (This has already been described)

(4) Spasm *above the cardia without obvious organic cause*

Cardiospasm (*Syn* œsophagectasia *achalasia of the cardia*)

In this condition there occurs a diffuse and considerable dilatation of the œsophageal lumen associated with a contraction of the cardia It is not a common condition but accounts for the great majority of cases of spastic obstruction

PATHOLOGY —In a well developed case the following changes will be found

(1) The œsophagus is markedly dilated in its lower part The dilatation gradually diminishes upwards and is virtually non existent in the cervical portion In no other form of obstruction does the degree of dilatation approach *to that found in this condition*

(2) The entire muscular coat becomes hypertrophied

(3) The œsophagus becomes lengthened *If this be marked the œso* phagus may assume an S shaped contour the lower convexity to the left

(4) In a late stage the muscular coat may atrophy the mucosa become thickened and later develop multiple ulcers

(5) The cardiac sphincter is in a state of tight muscular contraction and the mucosa thereof thrown into longitudinal folds There is no actual hyper trophy of the sphincter

ÆTIOLOGY —The condition occurs particularly in young adults of both sexes with a preponderance in females It may however occur at any age, and *Langmead* has described a case *in an infant of 16 months*

There are two theories as to the mechanism of the obstruction The older *view is that it is an intrinsic spasm of the sphincter According to Hurst it is* due to the failure of the sphincter to relax the result of a fault in the neuro muscular reflex He suggests degeneration of Auerbach s plexus as the *causative lesion In favour of this view is the absence of hypertrophy of the* sphincter and the degree of dilatation above in other words a reciprocal failure of sphincteric inhibition and of propulsive contraction above

RADIOLOGICAL FEATURES —The striking feature in a marked case is the œsophagectasia On observing the patient in the right oblique position whilst he is swallowing the opaque cream the latter is seen to slide down the dilated œsophagus and then to form a pool at or just below the diaphragm the level rising as the œsophagus becomes filled Very frequently the œsophagus is already partly filled with transparent contents in which case the

barium will be seen to sink slowly in blobs through these contents to the foot of the œsophagus The transparent fluid floats on top of the barium and is gradually lifted to the upper portion of the œsophagus At the junction level of barium and retained contents there is usually some admixture of the two particularly if the latter contains imperfectly masticated food The lower part of the dilated œsophagus is typically conical tapering smoothly to a point —the sphincter itself The smooth regularity of the cone is a diagnostic point If a filling defect be present in the lower end of the shadow it may be the result of a food residue This should be excluded by re examination before labelling as a carcinoma a case which otherwise presents the features of achalasia

As the obstruction is low down the dilated œsophagus displays considerable tolerance to retained contents A severe degree of œsophagectasia may contain when full 10 20 oz of fluid and tolerate without any discomfort 5 10 oz for a considerable time In many cases there is always throughout the day a residue of some ounces carried on from one meal to the next A residue up to twenty four hours is not uncommon

In the right oblique view the pointed termination of the barium shadow lies below the diaphragmatic domes as these are higher than the œsophageal hiatus immediately below which the œsophageal sphincter lies Sometimes a clearer outline of this diagnostically all important termination is obtained with the patient in the postero anterior position In this view the barium cone points downwards and to the left and again lies below the level of the dome In this view again the S curve of gross œsophagectasia is best demonstrated (Fig 18)

The obstruction at the sphincter is never absolute and rarely approaches to that degree As a rule when the œsophagus becomes full some of the cream escapes through into the stomach It is as though above a certain level or head of barium the sphincter relaxes sufficiently to bring the barium column down again to its threshold height

A useful fluoroscopic test of the degree of the obstruction is to ask the patient to cough In lesser degrees of the condition this act causes a jet of the opaque cream to pass into the stomach

Radiographic Control of Treatment—*In the treatment of cardio spasm* the first method to be tried is as a rule repeated dilatation of the sphincter by the mercury œsophageal bougie This is best passed in the first instance under fluoroscopic control The mercury filled lower end of the bougie is of course clearly visible and if a mouthful of comparatively dilute (and so translucent) barium cream be first given to outline the position of the sphincter the tip of the bougie can be manœuvred down against the orifice of the sphincter and its passage through into the stomach observed The tendency for the tube to lie horizontally and push out the left œsophageal wall may be counteracted by making the patient bend to the right or left The latter posture is more likely to be effective

Fig. 18. Three cases of cardiospasm of increasing severity from left to right. In the last case the lengthening of the gullet has caused slight tortuosity.

This method is successful in relieving to some extent the obstruction in cases of moderate severity It requires weekly repetition for some months, and the degree of its success in any case is indicated by the amount of the relief of the patient's symptoms and the subsequent radiographic appearance The latter are at first thought disappointing Even although the symptoms are largely abated, a considerable moiety of the œsophageal dilatation remains and some food residue will be held in the œsophagus If comparison with the radiograms taken before the treatment shows the œsophagectasia to be less and the threshold level of the residue to be lower the treatment may be regarded as satisfactorily controlling the condition

In the case of more drastic surgical treatment, such as forcible dilatation of the sphincter from below, or cardioplasty, the radiographic *restitutio ad integrum* is more complete, as the sphincteric control has been largely destroyed

Spasm from *Ulceration*

The causative ulceration may be peptic, tuberculous, or syphilitic All are rare the two latter extremely so A case of abscess of the œsophageal wall, following ulceration and causing obstruction, has been described

Peptic ulceration occurs in the lower part of the œsophagus, and is presumed to result from regurgitation of acid chyme from the stomach The symptoms are pain in the epigastrium and over the xiphisternum, precipitated by eating (especially dry foods) and heartburn The pain may last for half an hour after food The spasm is intermittent, and concurrent with the pain It may be demonstrated radiologically by a barium cream after preliminary excitation of the spasm by swallowing imperfectly masticated dry biscuit or toast

Idiopathic Spasm

The writer has seen one case of spasm of the œsophagus, about 4 inches above the cardia in which no cause was detected either radiographically or by means of the œsophagoscope The obstruction was intermittent, and the œsophagus above dilated as in cardiospasm The condition was kept satisfactorily under control by the periodic passage of a mercury bougie

ŒSOPHAGEAL OBSTRUCTION FROM EXTRINSIC PRESSURE

A large number of extrinsic lesions may cause œsophageal obstruction Chief among them are

Aneurism of the thoracic aorta
Neoplasm of the mediastinum, lung, or neck
Enlarged mediastinal glands
Abscess or new growth of the spine
Retro sternal goitre
Traction from fibrosed lung

Left sided interlobar empyema

Dysphagia lusoria

In general such sources of external pressure cause obstruction of the œsophagus only if they are situated in the neck or upper thorax Their characteristics are described in the section on the thorax

Fig 19 — Œsophagectasia following gross encephaloid carcinoma of the stomach

Gross pressure displacement of the gullet may take place in the lower thorax without causing any œsophageal symptoms

In obstruction from such causes the œsophagus if filled with barium will be seen to be displaced and its lumen reduced at the site of pressure to a curved rat tail streak widening out below to a normal calibre

IDIOPATHIC ATONY OF THE ŒSOPHAGUS

This rare condition has been described by *Rosenheim* and *Holzknecht and Olbert* It consists of a functional atony of the œsophageal tube without any organic or spastic obstruction While fluids pass freely down a thick barium paste passes very slowly and with mild dysphagia

ŒSOPHAGEAL DILATATION IN GASTRIC LESIONS

In certain gastric lesions such as carcinoma of the fundus high hour glass contracture high partial gastrectomy and other lesions causing marked diminution in the capacity of the stomach reservoir dilatation of the lower half of the œsophagus may occur The dilatation is similar to that of

a minor degree of cardiospasm, but the cardiac sphincter, instead of being closed, is widely patent (Fig 19)

ŒSOPHAGEAL VARIX

This condition, although a comparative rarity, is now known to be less so than previously supposed, as a result of the recognition of its radiographic features The varicose condition occurs in the lower part of the œsophagus and is caused by portal obstruction, in which condition it forms one of the channels of collateral circulation

Œsophageal varix presents a characteristic appearance in a radiogram taken to show the mucosal pattern of the œsophagus A fairly liquid opaque cream may be used, and the patient is best examined lying down The varicose mucosal folds are then seen outlined with barium A typical case cannot be mistaken for anything else A colloidal barium water suspension is the best medium to use, since this tends to deposit on the tortuous rugæ A Bucky grid should be used, to obtain the maximum contrast Preliminary atropinisation may help by keeping the mucosa "dry," and aiding the adhesion of the contrast medium

THORACIC STOMACH

Complete thoracic stomach as a congenital abnormality, with correspondingly short œsophagus is rare

Partial thoracic stomach is a less uncommon condition Both are described in the section dealing with diaphragmatic hernia

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PART ONE

SECTION II

STOMACH, DUODENUM AND DIAPHRAGM

CHAPTER IV

GENERAL TECHNIQUE

THE X RAY examination of the alimentary canal is in the main bound up with the use of contrast media The one in almost universal use now is barium sulphate This has superseded the bismuth preparations—the carbonate and oxychloride—for two reasons, the pharmacological effect of the latter and the relative costs The bismuth salts slow the rate of transit through the stomach and duodenum and are constipating in the colon Their transit is about twice as slow as that of barium sulphate—a disadvantage from the point of view of examination of the stomach and duodenum One advantage it possesses over barium sulphate is its soothing power in gastro intestinal lesions but barium sulphate has this to a slighter degree

Other contrast media which find occasional use are thorium salts and air

THE BARIUM EMULSION

The exact form of the vehicle of the meal is of no great consequence so long as it conforms to the following desiderata

(1) Consistency It must be fluid uniform in the distribution of the contained barium, and of the viscosity of a thin cream For the examination of the œsophagus a thicker cream may be required

(2) If for use in the investigation of the stomach and duodenum it should contain no food The presence of food in the meal so delays the opening of the pylorus as to make it difficult to study the latter and the duodenum satisfactorily

(3) Its taste and flavour must not be unpleasant

(4) It must retain the barium salt in satisfactory suspension for a reasonable length of time If properly proportioned it should maintain the suspension for an hour or two at least

Various excipients have been used in the past The first in common use was bread and milk a bad one because of its irregular texture Buttermilk, arrowroot, and other cereal preparations have been much in vogue, and still are

largely used In the writer's opinion they have the disadvantage, above referred to, of being foods If this is not objected to, they make admirable media for the suspension "Umbrose," a proprietary article containing, in addition to barium sulphate, dried milk, arrowroot, sugar, and chocolate, is widely used Horlick's Shadow food is another very satisfactory food containing preparation, and may be used with advantage as the first or "motor" meal in the double meal technique (*vide infra*) *Scott* contributed a definite advance in technique when he devised the food free barium emulsion, now so widely used

The following are the formulæ which the writer uses

	BARIUM MEAL	
	Barium Sulphate	℥ 10
	Saccharine	grs 2
	Raspberry Essence	♏ 45
	Gum Tragacanth	grs 60
	Aq ad	O 1
	BARIUM ENEMA	
(1)	Barium Sulphate	℥ 10
	Gum Tragacanth	grs 40
	Aqua Chloroformi	℥ 5
	Aq ad	O 1
(2)	Colloidal Barium Sulphate	℥ 10
	Aq ad	O 1

For ordinary œsophageal examinations the above meal formula is satisfactory In special cases its consistency may be stiffened by admixture of barium sulphate in powder form The barium sulphate must be in the finest subdivision possible It is now available in colloidal precipitation, and when in such form requires no tragacanth to suspend it, so fine are its particles The degree of subdivision of any specimen of barium may easily be observed under the microscope The particles should be fairly uniform in size Inequality in the size will render it difficult to maintain the emulsion for long The average size of the particles can be graded microscopically against a colloidal specimen

The barium emulsion is best made in an electric mixer Hand mixing with a mortar and pestle is a laborious process, and much less efficient

All the ingredients except the gum tragacanth should be sterilised, as should the container in which it is mixed, and the bottles in which it is stored This applies particularly to the barium meal emulsion Decomposition of this emulsion tends to occur on keeping it for long with the formation of traces of sulphides This phenomenon is instantly detectable by the smell on uncorking the bottle It may result from decomposition of the tragacanth, or from growth of mould on the surface of the liquid Such an occurrence is satisfactorily prevented by the addition of chloroform water, in the case of the barium enema, but the taste of this ingredient is objected to by many patients

and it is best omitted from a meal emulsion Hence the necessity for sterilising as many of the ingredients as possible and the use of fresh emulsions only Boiling the tragacanth destroys its emulsifying properties Benzoic acid added *to the amount of 25 o per cent , is an efficient preservative,* but some patients object to its taste also and complain of slight stinging or smarting in the throat after swallowing a meal containing it

TECHNIQUE OF THE BARIUM MEAL EXAMINATION

This is both fluoroscopic and radiographic Both are of importance the latter the more so It cannot be too strongly emphasised that the essence of a satisfactory X ray investigation of the stomach and duodenum lies in the taking of an adequate series of radiograms Not even the most prolonged and searching fluoroscopy *should be accepted as a substitute for this The two* methods are complementary and while neither should be dispensed with in many cases a series of radiograms provides all the information necessary The use of fluoroscopy alone however involves serious risk of an organic lesion remaining undetected

The number of minor variations in barium meal technique is legion and an attempt to indicate them all would fulfil no useful purpose

A complete technique should include radiographic study of both the com *pletely filled lumen of the stomach and duodenum and also the relief pattern* of the mucosa The latter assumes a relatively greater importance in certain cases such as chronic gastritis and the stomach after operation particularly when sphincteric control has been abolished Normally the study of the com pletely filled viscus is of greater importance but neither should be omitted

Time Intervals in Barium meal Examination

There are certain time intervals after the ingestion of a barium meal which are radiographically important affording as they do the best opportunity for investigating successive portions of the alimentary tract They form the basis *of a routine technique and are subject to variations to meet special cases*

(1) IMMEDIATELY AFTER —The first fifteen minutes after taking the meal is the vital period for the investigation of the stomach and duodenum It is *during this interval that the majority of peptic ulcers or carcinomata are best* demonstrated and it is important to take a series of radiograms at this stage *The stomach and duodenum should first be studied fluoroscopically and* radiographically after one mouthful of the medium to demonstrate the mucosal pattern Immediately following this the filled viscus should be examined

(2) ONE HOUR AFTER —Examination at this stage serves to determine the presence of early gastric evacuation of a barium ' rest in an ulcer crater *of duodenal and upper jejunal obstruction and of the gastric mucosal pattern* if this has not already been completely studied at the beginning of the meal

(3) SIX HOURS AFTER —This is an important stage It shows any pathological stasis in the stomach It is now generally accepted that delay in emptying of a lesser degree than six hours has with some exceptions, little or no significance, while any considerable six hour gastric residue is usually of pathological import

At this stage also the terminal ileum, appendix, cæcum and right colon may be studied The supine position is the most convenient for this purpose

(4) TWENTY FOUR HOURS AFTER —The appendix may be better demonstrated at this time than at six hours and the colon to a degree varying according to the distribution therein

(5) AT FORTY EIGHT HOURS AFTER and at succeeding daily intervals, *depending on the rate of colonic emptying*

With the above desiderata in mind, the routine of a barium meal examination must be planned according to the time that can be devoted to it

The routine of choice is to give a *single meal* and to follow it in a straight forward manner through the above stages In hospital practice, if the radiologist is able to pay a visit of a few hours only in the afternoon it may be impossible for him to examine the patient personally at every stage with a single meal technique and a compromise is sometimes adopted in the form of the *double meal technique* associated with the name of *Haudek* In this the patient takes at home the first or motor, barium meal, usually of the cereal type, with a content of 6 oz of barium sulphate He attends the X ray department six hours later For example if the motor meal be taken at 8 a m , the first attendance would be at 2 p m by which time the contrast medium will normally occupy the terminal ileum, cæcum and right colon After these portions of the tract have been examined and the presence or absence of gastric stasis noted, another meal is given and the stomach and duodenum investigated The patient is seen again an hour later, and on the following day if necessary

The method has the disadvantage that the first meal in the transverse colon may obscure the pyloric and duodenal regions to some extent

PRELIMINARY PREPARATION

Aperients —This is a matter on which conflicting views obtain Some radiologists order an aperient as a routine on the day before the examination, whilst others allow one to be taken if it is the patient s daily habit The writer is opposed to both these courses, on the grounds that an aperient taken the day before is apt to disturb the normal (or pathological) transit of the meal through the alimentary canal A safer plan is to avoid all aperients if possible, and if the patient s colonic habit makes some relief necessary, to give an aperient two days before, and an enema on the evening before the examination An exception to this rule is when the appendix is suspect An aperient tends to empty the appendix, and so ensure its subsequent filling with barium

In such cases an aperient should be given as a routine on the day before the examination

Drugs —All medicaments containing bismuth, phosphorus, calcium, or other drugs of a high atomic weight should be withheld during the examination, and for a day or two before Magnesium carbonate and sodium bicarbonate may be taken as required

Food —In the single meal technique the ideal is to withhold all food on the morning of the examination, if the first examination is to take place say, at 10 a m This is imperative if the patient be suffering from pyloric obstruction or stenosis In some cases, however, this rule may be relaxed and the patient allowed a cup of tea and a small piece of dry toast two hours before the examination Although this is a relaxation appreciated by the patient, it should be permitted only when the state of the stomach and duodenum is not in question

Between the first sitting and that one hour later, no food or liquid should be taken If a restorative such as brandy or sal volatile, is really necessary because of the patient's general condition it should not be withheld

Between the one and six hour examinations it is the practice of many again to allow no food but this is in most cases an unnecessary deprivation, and unless there is present a gross gastric stasis a light lunch of fish or eggs is permissible without detriment to the investigation Subsequent to this there are no radiological indications for dietetic restrictions

The preliminary preparation for the double meal technique is similar, with the following variations (1) In lieu of breakfast on the morning of the examination the cereal barium meal is taken This contains food and so sustains the patient (2) No food or liquid is allowed between this and the first examination six hours later

In the later stages, when the colon is being studied, no aperient should be allowed

In cases of severe colonic stasis however, this rule cannot be applied for too long With each succeeding day, if no action of the bowels takes place, there is an increasing inspissation of the barium, with formation of scybala and if a partial organic obstruction be present in the left half of the colon a serious exacerbation may result from neglect of this point.

CHAPTER V

THE NORMAL STOMACH

ANATOMY

THE STOMACH is usually described in three portions the fundus or pars cardiaca body or pars media and pyloric antrum or pars pylorica

The fundus lies above the level of the cardiac orifice or cardia the pyloric antrum is the portion lying between the incisura angularis and the pyloric canal or pylorus and the body is represented by the intervening portion (Fig 20)

Form of the Stomach—This is very variable depending chiefly on the habitus of the patient It is usual to describe three types of stomach, hyper tonic orthotonic and hypotonic corresponding to the three types of habitus the hyper ortho and hyposthenic The normal stomach may show an infinite series of gradations between these limits and the criterion as to its normality in this respect is that it should conform to the general habitus The three types of stomach are commonly likened to a steerhorn or cowhorn a J and a fish hook respectively

Anatomical Relationships of the Stomach—Certain relationships are of radiographic importance The fundus is in relationship above and behind with the diaphragm and in front with the under surface of the liver

The anterior surface is in contact with the anterior abdominal wall The posterior surface lies against the stomach bed composed of from above downwards the diaphragm spleen pancreas and duodeno jejunal flexure To the left are the splenic flexure and the adjacent limbs of transverse and descending portions of the colon

The stomach bed was previously held to be in posterior apposition to the whole of the stomach Radiology has shown that the lower half of the stomach lies below those limits The pancreas forms a transverse ridge which slightly indents the stomach near its middle so that in a lateral view the upper half of the stomach is inclined downwards and forwards whilst the lower half is perpendicularly disposed An exception to this is the hypertonic type in which most of the stomach is apposed to the stomach bed This pancreatic ridge is responsible for the posterior (pancreatic) incisura of *Twining* described later

TECHNIQUE OF EXAMINATION OF THE STOMACH

The examination should be commenced with the patient in the erect position in the screening stand The patient is instructed to swallow a

mouthful of the barium cream, and this is observed in its passage into the stomach With the right gloved hand this bolus is pushed into each part of the stomach in an attempt to "whitewash" the mucosa In this way the mucosal pattern may be observed fluoroscopically, and an abnormality therein detected After recording this radiographically in the supine or prone position, if the view in the erect position fails to show the pattern in the upper portion of the stomach satisfactorily the stomach is then filled, its filling being watched the while As the capacity of the stomach varies, the amount of the barium cream necessary to visualise its lumen will also vary An average amount is 10–12 oz

When the stomach is filled, certain further points must be determined fluoroscopically, *and should be noted as a routine They are the position of* the stomach its tone and peristalsis the flexibility of the gastric wall, and the *presence of any persistent irregularity of its contours* The patient is then rotated into both oblique positions to bring into view the anterior and posterior walls of the stomach and at times a true lateral position may be necessary to show a posterior wall ulcer in profile The pylorus may not be filled at first, but if not firm palpation with the gloved hand will serve to push some of the cream through it into the duodenum Certain points should be noted in this important procedure

It should be carried out with the tips of the four fingers of the right hand, by a progressive massaging movement upwards and to the patient's right In the hypotonic stomach the pressure will be more conveniently exerted by the ulnar border of the hand and in an upward direction

The pressure should coincide with a peristaltic wave, that is to say, when a wave has progressed about half way down the pars pylorica, and the prepyloric *portion contains a rounded mass of barium Immediately after this* the pylorus tends to open of itself and little or no pressure may be required to fill the pyloric canal and duodenal bulb

If the stomach is very hypertonic the pylorus and bulb may be hidden behind the superimposed shadow of the pyloric antrum Rotation of the patient into the first or right oblique position (and, often, into the left oblique) will then bring these structures into view Again, if the stomach be hypotonic and of the fish hook type the second portion of the duodenum may be directly behind the pyloric canal in the true postero anterior view, and a similar rotation of the patient be necessary to separate their superimposed outlines

Frequently the resting stomach contains an ounce or two of secretion and the barium meal when taken is apt to float part of this up into *the pyloric* antrum where it is held trapped, as in the distal limb of a U tube Such a *state of affairs is evident* as a horizontal barium level *in the pyloric antrum* Before the pylorus and duodenal bulb can be visualised, this trapped resting juice must be forced through *into the duodenum, a process* which may require several palpatory manipulations each coinciding with a peristaltic wave If

the pylorus be normal not more than half a dozen such manipulations are as a rule necessary

During the fluoroscopy the relationship of any tender pressure points to the gastric and duodenal shadow should be noted and also the relationship of any tumour mass palpable clinically As it is frequently difficult to feel such a mass with the examining hand encased in a thick lead rubber glove it may be necessary to mark the site of the mass by a ring of thin wire fixed to the abdominal wall with adhesive strapping It is best to investigate this point with the patient supine and quite imperative that both procedures the delineation of the tumour by the wire ring and the radioscopic palpation should be performed without moving the position of the patient

After the fluoroscopic examination has been completed it remains to take a series of radiograms These are of prime importance because of the difficulty of detecting fine changes radioscopically and as one important proof of the organic nature of an abnormal appearance is in its constancy that constancy must be demonstrated in several radiograms This is particularly applicable to the pylorus and duodenum

The precise position of the lesion suspected will determine the position in which the radiogram is taken—e g for the fundus the supine position is the most suitable—but as a routine at least two radiograms of the whole stomach and duodenum should be taken and at least four of the pyloro duodenal area Some form of serial apparatus is desirable for these last The *Beclere* serial apparatus and the *Berg* apparatus are admirable but require dual control A convenient and simple form is that devised by *Riddell* In the writer s modification of this there is an aperture 6 × 5 inches in the centre of a lead backed frame so arranged that the four quarters of a 12 × 10 inch film can be brought successively in front of the aperture and exposed Four 6 × 5 inch radiograms of a suspected area are thus conveniently arranged on one film and can readily be compared one with the other The disadvantage of this apparatus is that it is blind i e some few seconds must elapse between screening and the taking of the first picture The *Berg* and *Beclère* types of apparatus on the other hand make it possible to radiograph a suspected area within a second of seeing it fluoroscopically and so enable one to choose the most satisfactory phase in a peristaltic cycle for the purpose of its demonstration

Compression —Some form of compression is frequently required with the patient erect to demonstrate such points as the upper portion of a stomach which is hypotonic and in which the barium has sagged into a dependent pool to ensure complete filling of the duodenal bulb etc The most useful for this purpose are a series of lambs wool pads of various thicknesses and sizes An obvious corollary of this is that the screen and cassette holder of the upright stand should be sufficiently rigid to exert firm pressure

Berg has drawn attention to the necessity for what he calls graduated compression and aimed exposures in the radiographic demonstration of duodenal

ulcer He points out that a radiogram taken without compression may entirely fail to demonstrate a duodenal ulcer on the anterior or posterior wall of the duodenal bulb—*en face* in other words—while suitably applied compression may empty the duodenal bulb sufficiently to bring it into relief He has devised for this purpose a special serial compression apparatus for use with an upright screening stand—the so called *Berg explorator* This is undoubtedly the most satisfactory type of apparatus of this nature at the time of writing A simple substitute is a pyramidal lambs wool pad This is very effective when carefully applied It is best made up of four square pads of lambs wool each in a calico cover and sewn together with tapes in the form of a step pyramid The largest pad at the base of the pyramid is conveniently backed with three ply wood and the whole arrangement of pads enclosed in a pyramidal calico casing

The *Chaoul compression band* in which pressure is exerted by the inflation of a hemispherical rubber band strapped by webbing to the abdomen is difficult in practice to apply accurately

THE MUCOSAL RELIEF PATTERN OF THE STOMACH

It is only recently that much attention has been paid to this aspect of gastric and duodenal X ray examination particularly as a result of the work of *Forssell Berg* and *Chaoul*

Technique —Frequently the mucosal pattern can be demonstrated with the standard barium cream either after a few mouthfuls have been taken or at the end of an hour when the stomach is nearly empty Excess of mucus or secretion may prevent this as will too thick a meal In doubtful cases therefore in which a relief picture is of importance steps must be taken to ensure that the stomach is quite empty and a special contrast medium used The examination is best conducted early in the morning with the patient fasting overnight A thin colloidal barium cream with no tragacanth may be effective or a thorium oxide suspension such as diagnothorine This is a colloidal suspension which is supposed to flocculate on reaching the mucosa and so to produce a thin coating over its surface About ½ to 1 oz of either of the above media is sufficient and should be taken lying down Too much obscures the pattern The patient then lies on each side and then prone to coat the whole mucosa

Screen examination will show the best position for a radiogram usually prone

In the study of the mucosal pattern the following points must be noticed

(1) Complete absence of the rugæ as in atrophic gastritis or linitis plastica

(2) Localised absence as in carcinoma

(3) Interruption and puckering from ulcer

(4) Increase in size of the rugæ and increased tortuosity both met with in hypertrophic gastritis

(5) Abnormal persistent flecks or barium rests in an ulcer crater or carcinomatous crevice

AIR INSUFFLATION OF THE STOMACH

Duval and *Beclere* have developed a technique for investigating the stomach after distension with gas In their method an Einhorn tube is swallowed by the patient The stomach must be quite empty, and any fluid residue should first be drawn off through the Einhorn tube The stomach is then slowly inflated under fluoroscopic control Care must be taken to avoid undue distension The inflation apparatus may with advantage include a pressure gauge and if the patient experiences any pain during the inflation, the administration must be stopped and a little air released from the stomach

This method is of greatest value when combined with a whitewash method—the *couche mince* of these authors The thin coating of barium or of thorium on the mucosa throws it into greater relief when there is the added contrast of the air distension Erect, prone, supine, lateral, horizontal and Trendelenburg positions may all be necessary in different cases, depending on the site of the lesion to be studied A tilting table is of great convenience in this technique

The "blind" method of insufflation, by Seidlitz or similar powders, is unsatisfactory, since the degree cannot be controlled, and fluid is introduced at the same time

These authors state that valuable information may be obtained regarding

Encephaloid Carcinoma —In this condition the mass may be seen protruding into the air filled lumen and the site of origin of the growth may be determined

Gastric Polypi —According to those authors, the number and disposition of the polypi can be determined, and pedunculation made out

In Peptic Ulcer this procedure is contraindicated, for fear of perforation

Pancreatic Tumours —A lateral radiogram, taken with patient lying prone, may show the tumour mass projecting into the gas filled stomach

The method is as yet relatively untried, and in the majority of cases it is improbable that it offers advantages over the more established methods commensurate with the risks of perforation and the unpleasantness of swallowing the Einhorn tube In certain cases of exceptional difficulty or obscurity it may, however, be a diagnostic measure of considerable value

The most convenient time to conduct the pneumogastric examination is in the evening, six to eight hours after the ordinary barium meal The patient should fast during that day.

NORMAL APPEARANCE OF THE STOMACH IN THE ERECT POSITION

Before the meal is given the gastric fundus only is visible, outlined by gas This gas bubble, variable in size, is pear shaped, apex downwards, if th

stomach is empty If there is any considerable amount of resting juice in the stomach the gas bubble may be limited below by a horizontal fluid level

When the opaque cream is swallowed it is held up for a few seconds on passing into the stomach just below the cardiac orifice and gradually slides down the lesser curve to the lower pole In an empty stomach of good tone the barium does not form a pool at the lower pole but canalises the stomach as more of the meal is taken until gradually the whole gastric lumen is distended and filled with the opaque medium with the exception of the gas filled fundus The upper level of the barium emulsion forms with the gas above it a horizontal level and any secretion already present in the stomach forms a superficial fluid layer between the two

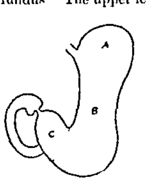


Fig 0 —Subdivisions of the stomach (a) Fundus fornix or pars cardiaca (b) Body corpus or pars media (c) Pyloric antrum or pars pylorica

Cardiac Orifice —In most cases in the erect position this orifice is above the level of the barium but if the gas bubble be very small or absent it will be visible as a puckered projection of the barium shadow Immediately below it there is sometimes a projection to the left of the lesser curve which may simulate *an ulcer niche Indeed it may be impossible to differ*entiate radiographically between them The cardiac orifice is however best demonstrated in the supine position

The Lesser Curve presents with the above exception a smooth regular contour down to the incisura angularis where it turns upwards on itself the acuteness of this blunt angulation depending on the type of stomach From the incisura angularis to the pylorus the lesser curve is similarly regular but sometimes presents a small notch about $\frac{1}{8}$—$\frac{1}{4}$ inch in depth a little short of the pyloric canal This is due to a mucosal fold and is not pathological Any *irregularity of the lesser curve either a protrusion or a defect* should be regarded as representing an organic lesion until it is proved to be the reverse

The Greater Curve, on the other hand is more variable in its contour Normally smooth and undulated by peristalsis it may present a notched appearance from several causes one of which not being pathological concerns us here If the colon in the region of the splenic flexure be deeply haustrated and be lying closely apposed to the greater curve of the stomach it may produce a series of indentations in the latter corresponding to the haustral bulges in the colon This type of indentation has to be distinguished from those caused by increased rugosity of the gastric mucosa and gastrospasm respectively

The Lower Pole is high in position and of mild convexity in the hypertonic stomach and low and parabolic in outline in the hypotonic In very hypotonic stomachs its contour becomes bulbous the barium tending to form a pool in it This degree is probably *over the borderline of the normal The limits*

of the normal level of the lower pole are a matter of dispute The intercristal line (the modern equivalent of the old halfpenny on the umbilicus) was formerly given as the lower normal limit but it is now recognised that lower levels are compatible with normal health Probably a point half way between the inter cristal and pubic levels marks the normal lower limit

The Pylorus, when seen in profile is a short regular canal about ¼ inch in length Its contours are perfectly smooth and join the lesser and greater curves in blunt right angles Its calibre as seen in a radiogram depends on the degree of relaxation of the pyloric sphincter and varies from nil up to 5 6 mm The pyloro duodenal junction is also normally very regular often geometrically so and can be compared with the junction of the stem and body of a mushroom

The direction of the long axis of the pyloric canal depends on the type of stomach In the hypertonic type it is directed backwards *to the right and slightly up* wards In the orthotonic it is upwards slightly to the right and slightly backwards while in the hypotonic type it is either directed upwards or upwards and slightly to the left

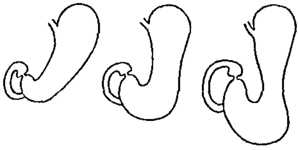
FIG 1 —Normal orthotonic stomach

The position of the pylorus in the abdomen also varies with the type of stomach The lesser the tone the lower its level is Normally it varies between a point midway between the xiphisternum and umbilicus and the umbilicus itself It is held by some authorities that it descends to a lower level only in cases of gastroptosis

Tone of the Stomach —Apart from pathological variations the gastric tone follows the habitus of the individual being greatest in the hypersthenic

individual, and least in the hyposthenic Its estimation is simple when the stomach is filled with barium emulsion, by comparison of the relative widths of the upper and lower parts of the gastric lumen, and the general conformation of the stomach

In hypertonus the stomach is "steerhorn" in shape, its lumen largest above, and tapering to the pylorus The incisura angularis is feebly represented, and the greater curve descends only a small distance below the pyloric level *Indeed in marked hypertonus the pylorus may be the lowest point of* the stomach (Fig 22)



1 2 3
Fig 22 —Three normal types of stomach 1 Hypertonic 2 Orthotonic and 3 Hypotonic

In orthotonus the stomach is J shaped, the incisura angularis is fairly well marked, and the lower pole of the stomach about equal in calibre to the upper portion of the pars media The most dependent portion of the stomach lies about the intercristal level

In the hypotonic stomach its form is fish hook The greater curve at the lower pole tends to sag down, making the lumen there larger than elsewhere The lumen of the pars media collapses from incomplete filling and dragging The most dependent portion of the greater curve may *reach half way between the umbilicus and symphysis pubis*

Apart from habitus there are various other factors which modify gastric tone Vagal stimulation increases it and sympathetic stimulation does the reverse Psychic factors may have a marked temporary effect Fear and depression diminish tone as does nausea from an unpleasant taste—e g of a badly flavoured barium meal ! Conversely it increases during excitement

The effect of gastric biliary and duodenal lesions is variable but as a rule *the first depresses it If a gall bladder lesion has any effect, it is usually* depressing while a duodenal lesion may do either

Peristalsis —The peristaltic waves in the stomach begin high up in the pars media where they are very shallow As they spread downwards they *become deeper but this deepening is chiefly on the greater curve until the* incisura angularis is reached Above that point the peristaltic undulations of the lesser curve are very small By the time it has passed the incisura angularis *the wave has become deep, and about midway between that point and the* pylorus completely obliterates the gastric lumen trapping a portion of the gastric contents in front of it If the pylorus has not opened, a reflux takes place past the peristaltic ring but after a few such abortive waves the pylorus opens, and a mass of barium is expelled into the duodenal bulb, which it fills

Successive waves form behind each other at such rate that two or three are visible in the stomach at any instant

It is held by some that the initial wave occurring after a resting phase when food is taken commences at the level of the incisura angularis, that is at the lower pole where the first distension of the gastric wall by food takes place The writer has not been able to satisfy himself that this is the case

Apart from obstructive atony of the stomach the gastric peristalsis is related to its tone being most marked in hypertonus and least in hypotonus In the exception mentioned above the stimulus of food usually induces a short bout of violent hyperperistalsis followed by complete cessation

Hyperperistalsis is not a physiological condition It may be due to a number of causes and is of two types obstructive and non obstructive The former occurs in pyloric and duodenal obstruction (q v) Non obstructive hyperperistalsis is most commonly due to duodenal ulceration but may result from a biliary or appendicular lesion and in achlorhydria It shows in a radiogram by a larger number of waves smaller than the normal Instead of two or three waves there may be as many as six or seven present at the same time The length of each wave is smaller and the rate of progression faster (Fig 23)

FIG 23 —Gastric hyperperistalsis

The " Antral Sphincter —After much conflict of opinion the existence or not of this sphincter, which has for years been described by physiologists has

been decided in the negative, chiefly as a result of the cinematographic work of *Forssell* and *Kaestle* The appearance of the sphincter is due merely to the deepening of the pyloric waves in the pyloric antrum As one sweeps on towards the pylorus, another forms behind it, and the progressive nature of these contractions rules out the theory that there is any true sphincteric action

Cascade Stomach (*syn* "cup and spill" physiological hour glass, estomac en coupe a champagne)—This curious appearance is one of loculation and marked dilatation of the fundus The contrast medium passes through the cardia into the fundal loculus, the lower part of which it fills It then spills down into the lower part of the stomach, a semi-elliptical pool remaining above Ballooning of the fundus is a common feature in these cases (Figs 24 and 25)

Fig. 24 —Mild degree of cascade stomach

The lateral view shows the loculation to be due to the posterior wall of the stomach *forming a shelf*, which traps the meal in a shallow trough When this is filled to the brim the barium spills over in front and fills the lower stomach At times the lower portion of the stomach is rotated and displaced to the right, and drawn upwards In other cases only the upward displacement exists

Several causes are assigned to *this condition*

(1) Distension of the Splenic Flexure with Gas —This, causing pressure on the posterior wall of the stomach just below the level of the cardiac orifice certainly accounts for a certain number of cases Dispersal of the gas results in the stomach assuming its normal position and contour

(2) Localised Muscular Hypertonus, with associated fundal ballooning, particularly of a band of oblique fibres in the lower posterior part of the fundus The cause of this is unknown

(3) *Localised Spasm and*

(4) Contraction of Perigastric Adhesions may produce a similar appearance but, as pathological lesions, should be excluded from the classification of "cascade stomach"

Not infrequently the cascade effect is so gross as to produce a complete hour glass appearance In cases of this degree the splenic flexure is usually coiled in the left cupola Another curious effect that is occasionally produced is a blunt projection high up on the lesser curve It must not be mistaken for an ulcer

NORMAL APPEARANCES IN THE SUPINE POSITION

With the subject in this position the spine and structures in front of it act as a watershed separating the contents of the stomach in two unequal portions a small pyloric and a large fundal Most of the opaque meal falls back into the fundus and this position is the most satisfactory for the demonstration of that portion The contour of the *fundus* may be quite regular and smooth or may show a series of indentations regular in character from mucosal folds The presence or absence of these mucosal notches depends on the degree of the gastric tone at the moment and the amount of its contents (Fig 26)

The *pars media* is as a rule incompletely filled Any gas present tends to collect in this the highest part of the stomach in the supine position As a rule the rugæ are visible from a coating of barium The stomach has a higher and more transverse disposition in this position than in the erect The duodenum is likewise higher This postural displacement upwards varies in degree from 1 to 4 inches or more depending largely on the tonic type It is greater in the hypotonic

Fig 25 —Marked cascade stomach postero anterior and lateral views

The pyloric antrum usually contains a small amount of the opaque medium, in a mass separate from the fundal pool If, however, gastric tone be marked,

and if no gas be present the two shadows may be joined by the barium filling up the pars media

If there is a sufficiency of barium in the pyloric antrum the pyloric canal and duodenal bulb may be well visualised as a rule however they are better seen in the erect or prone postures The supine frequently fails to provide a column or head of barium cream sufficient to promote complete filling of the duodenal cap

F W Twining in a personal communication has drawn attention to an anatomical variation which he calls the posterior (pancreatic) incisura He

Fig 6 Normal stomach appearance in the supine position

ascertained by studying the stomach in lateral films in the supine position that the pancreatic ridge often causes an infolding of the gastric wall If this infolding reaches the surface of the barium (in the supine position) an incisura is formed which may either cross the stomach or only reach half way across it Behind this infolding of the gastric wall a triangular filling defect is present representing the body of the pancreas itself (*vide* section on pancreas) The infolding therefore simulates a true spastic incisura in the supine postero anterior view from which it may be distinguished by two features (*a*) it is crossed by mucosal folds (*b*) it disappears in the prone position It occurs usually in ptotic women

NORMAL APPEARANCES IN THE PRONE POSITION

In this position the gravity relationships are reversed. The fundus is much the highest, the pars media and pyloric antrum in front of the spinal column the most dependent, and the pylorus and duodenum intermediate. Most of the opaque medium will therefore tend to gravitate to the pars media and pyloric antrum, and gas in the stomach to rise to the fundus and pylorus. All the gas can be collected in the fundus by asking the subject first to lie on the right side before turning into the prone position.

The fundus will therefore be incompletely outlined. The mucosal pattern of the fundus, however, frequently stands out well (Fig. 27). The pars media and pyloric antrum are well outlined, and peristalsis in them is usually more active than in the erect position. The pyloric canal and duodenum nearly always fill satisfactorily. In this view quite well-marked peristaltic waves are seen on the lesser curve. Indeed, in the very hypotonic types of stomach this may be the only position in which to see these two structures properly outlined. If, as occasionally happens, the pyloric antrum overlies the pyloric canal, slight rotation of the subject will separate the two shadows. The mucosal pattern of the pars media is easily demonstrated in this posture by the insertion under the epigastrium of a wool pad of suitable thickness. The exact size must be determined by trial in each case.

FIG. 27.—Normal mucosal pattern of fundus and pars media, prone position.

NORMAL APPEARANCES IN THE ERECT LATERAL VIEW

In a true lateral view the gastric shadow presents a mildly bilocular appearance: two oval cavities connected by a narrower isthmus. It may be compared with an old fashioned sac purse. The upper or fundal loculus slopes downward and forwards, the lower loculus hangs vertically downwards. This applies particularly to the hypotonic stomach. For the hypertonic type there may be seen no such biloculation. The pyloric canal is not visible in the true lateral view: a little rotation will bring it into view in front of or behind the stomach. Behind the lower pole of the stomach will be seen the duodenum and duodeno-jejunal flexure.

This view, of which, owing to the relative thickness, it is difficult to obtain very sharp radiograms, is chiefly of value in the demonstration of anterior or posterior wall lesions, or to obtain profile views of the stoma and adjacent loops in cases of gastro-jejunostomy, anterior or posterior.

THE GASTRIC MUCOSA

The classic description of the gastric rugæ is as follows

Four longitudinal rugæ, two anterior and two posterior, begin at the cardia and run down close to the lesser curvature to end at the pylorus. These four are described as forming the *magenstrasse* under the impression that they constitute the channel for the downward passage of food to the lower pole, to the exclusion of the rugæ nearer to the greater curve. *This exclusive action of the majenstrasse* is a myth. Three or four additional longitudinal rugæ on each wall are described between the *majenstrasse* and the greater curvature. These begin in the fundus of the stomach and end in the lower pole (Fig 28). These longitudinal rugæ become increasingly irregular the nearer they are to the greater curve, and show a tendency to become broken up into secondary transverse and oblique rugæ (Figs 29 and 30). *Chaoul* regards this arrangement to be static and modified only by the elastic stretching and contraction of the mucosa as a whole in response to varying distension of the stomach.

Fig 28 Normal mucosal pattern in stomach of rather a fine type

The modern view, however, on the form and functions of the gastric mucosa is based on the researches of *Forssell*. In 1923 this worker first stated his autoplastic theory, that of the automatic functional motility of the gastric mucous membrane, and thereby gave a satisfactory reason for the existence of the muscularis mucosæ. Prior to his paper that muscular layer was not known to have any significant functional activity. *Forssell's* theory is

in brief, that the gastric mucosa can adapt its rugæ, in response to the stimulus of food, into such a form as is best suited to promote digestion, and that this activity is a local autonomic response, *and not dependent on distant nervous control* The particular value of his work lies in the attention he has drawn to the great variation which may occur physiologically, and to the changes which may take place in gastric disease

Forssell's work extended also to the duodenum, small intestine and colon, although it is in the stomach that the phenomena can best be studied

Berg and *Albrecht* have elaborated his work, and recently *Kadrnka* has given an account of the physiological changes that may occur

Chaoul does not accept *Forssell's* views, and holds that the rugosity of the gastric mucosa is governed by the distension of the viscus but the latter's views are probably nearer the truth It is possible that both are to some extent right, that the longitudinal rugæ along the lesser curve are anatomical, that those near the greater curve are autoplastic, and that both factors control the intermediate ones

FIG 29 — Normal mucosal pattern of stomach duodenum and jejunum

The mechanism of the physiological changes in the gastric rugæ is, according to *Forssell,* twofold — the autonomic activity of the muscularis mucosæ and the varying vascularity of the mucosa and submucosa The former determines the number and shape of the folds, and the latter, by a varying degree of turgidity, controls to some extent their size and coarseness

Kadrnka has described the following changes in the gastric mucosa under varying physiological and pathological states

Physiological

(1) MODIFICATIONS RESULTING FROM PROGRESSIVE DISTENSION WITH BARIUM EMULSION —When the stomach is relatively empty the rugæ are few and coarse As the viscus is filled the transverse rugæ become smaller but at the same time more numerous This occurrence is inexplicable by *Claoul's* theory If the gastric rugæ were dependent on the contractility of the muscular coats distension would obviously efface them gradually but would not add to their number

FIG 30 —Normal mucosal pattern in stomach outlined with colloidal barium

(2) MODIFICATIONS DUE TO THE PRESENCE OF FOOD IN THE STOMACH —This when tested by the addition of yolk of egg to the thin contrast medium resulted in enlargement of the mucosal folds and their re arrangement In this connection *Forssell* described in the dog the formation of actual mucosal pockets surrounding particles of meat to which he gave the names of *fossettes* or *alveoles digestives* The muscularis mucosæ and vascular engorgement are both said to take part in the formation of these lacunæ These fossettes do not occur in the human subject Experimentally it was found that if the ingested meat is in comparatively large fragments the enlargement of the rugæ is con siderable in the attempt to engulf them

(3) INFLUENCE OF EXTRANEOUS FACTORS —Cold tends to make the rugæ smaller and more numerous both in the stomach and colon Pilocarpine *has the same effect and atropine the opposite These changes are however* not constant

In the colon castor oil tends to enlarge the rugæ by vascular congestion while saline purges by dehydration have the reverse effect

Pathological

The changes in the appearance of the gastric mucosa in different diseases of the stomach are described under their respective headings but may be summarized as follows

EXTRINSIC PRESSURE —Displacement spreading and disappearance of the folds These changes occur only when the pressure is considerable

INFLAMMATION —Thickening irregularity and stiffness of the rugæ According to *Berg* a verrucose stage may be reached in chronic inflammation In atrophic inflammation no change is visible as a rule In gross atrophy they may disappear

ULCER —Convergence of folds (which may be thickened) on the crater Erosions are usually undemonstrable

NEOPLASM —Obliteration of the rugæ and irregular protuberances and craters on the growth itself

RATE OF GASTRIC EVACUATION

In the consideration of this there must be noted

(1) The time of commencement of evacuation
(2) The time of evacuation of the main bulk of the meal
(3) The time of evacuation of every trace of the meal

Variation in the time of all three may occur according to the type of stomach the type of meal and the pyloric function

Taking as a standard the orthotonic stomach a normal pyloric function and a food free barium cream as the contrast meal gastric evacuation should commence in about one minute after ingestion of the meal The main bulk of the meal should have left the stomach in an hour and every trace in two to three hours Frequently the last time factor is lengthened even in the normal and there may be retained in the stomach a small trace of barium up to six hours If the above first and second time intervals are normal the latter is of little significance provided the patient is fasting and has not been lying down A small six hour residue is common in hypotonia and results from gravity It can as a rule be freely expressed through the pylorus by manual pressure thus differentiating it from a residue due to pyloric obstruction spasm or achalasia A poorly suspended barium emulsion tends to produce a streak residue at the lower pole by sedimentation This is completely prevented by the supine posture and is not seen in cases confined to bed

Haudek first laid down the rule that a six hour gastric residue indicates a pathological condition but this is true only if the residue be of some size say one fourth to one third of the meal and even then it may be due merely to gross hypotonia and ptosis and not to pyloric obstruction

The Influence of Various Factors on Gastric Evacuation

(1) TYPE OF MEAL —The presence of any food and particularly fat lengthens all three times Bismuth in place of barium has the same effect and is said approximately to double the time of evacuation compared with barium

(2) TONUS OF THE STOMACH —Hypertonus speeds up the second and third time intervals, and hypotonia slows them Neither has very much effect on the time of commencement of evacuation, unless the hypotonia be so marked as to approach atony

(3) PERISTALSIS OF STOMACH —The degree of peristalsis influences all three times directly

(4) PYLORIC FUNCTION —Variation in the normal pyloric function affects all three points in the rate of evacuation

(a) Undue Patency —This may be organic, as in a scirrhous carcinoma of the pylorus or functional, as in a carcinoma not involving the pylorus or a simple achylia In each case the stomach empties rapidly

(b) Achalasia of the Pylorus —This term is used by *Hurst* to describe a condition in which the pylorus relaxes infrequently by itself while pressure readily forces food through into the duodenum It delays the evacuation times

(c) *Pylorospasm* —In this reflex condition, most commonly the result of a gastric or duodenal ulcer the pylorus is obstinately shut at first, and after about fifteen minutes commences to relax and allow free gastric evacuation Pylorospasm therefore affects principally the first time factor, that of commencement of evacuation, and the other two to a lesser extent It at first simulates organic obstruction, a simulation disproved by the later course of evacuation

(d) *Organic Obstruction* —With this all three times are markedly lengthened The last factor may spread over into the following day a state of affairs practically pathognomonic

THE ACT OF VOMITING

If the stomach be observed under the screen during the act of vomiting the following sequence of events is seen

The diaphragm rises with the increase in abdominal pressure The body and pyloric antrum contract vigorously and the stomach takes on a peg top shape The fundus remains dilated and the gas bubble disappears with the opening of the cardiac sphincter Combined contraction of the abdominal muscles diaphragm and stomach ejects the gastric contents up the œsophagus After the act has been completed the stomach gradually relaxes and assumes its normal contours

CHAPTER VI

GASTRIC ULCER

Radiology has revolutionised the diagnosis of peptic ulcer, and its differentiation from other organic disease in the abdomen and from the functional dyspepsias It has removed this lesion from the realm of diagnostic guess work and established it as one of the most easily diagnosed, in the ordinary type of case

The barium meal examination, if thoroughly and efficiently carried out, is by *far the most accurate method of investigation in suspected peptic ulcer*, and in the majority of positive cases demonstrates the lesion beyond all doubt *or argument* This supremacy as a *diagnostic method is of comparatively* recent growth, and is dependent on careful and accurate technique In *the hands of the inexpert or careless it can be so misleading as to be dangerous* This last requires emphasis now in a way it did not twenty years ago Twenty years ago, or even later, radiological investigation of the stomach was so much in its infancy that undue reliance was not placed on its results Nowadays the profession has been educated to rely on the accuracy of the radiological method in organic gastric disease to such an extent that, unless the clinician is also versed in the technical aspect of radiology to some extent, he may be misled by inefficient radiological investigation in a way that would not have been possible in the past

Peptic ulcer may occur in any of the following sites oesophageal, gastric, pyloric, duodenal, jejunal

Oesophageal peptic ulcer is *rare, and has been mentioned in the section* on the oesophagus

Gastric and duodenal ulceration are, *on the contrary, common conditions*, and constitute by far the commonest lesions found by X ray examination of the stomach and duodenum Of the two, duodenal ulcer is the more common.

Walton has pointed out the very varying ratio between gastric and duodenal ulcer recorded by different authorities, which he quotes as follows

	G U Per cent	D U Per cent
Pick	27	73
Mayo	26	74
Moynihan	24	76
Sherren	54	56
Walton	59	41

Walton's figures for duodenal ulcer are surprisingly low The writer's figures, in common with those of many other radiologists, are of the order of 4 to 1

Duodenal and jejunal ulcer are described in their appropriate sections

PATHOLOGY OF GASTRIC ULCER

Gastric ulcer may be acute subacute or chronic It is now held that all peptic ulcers of the stomach begin as acute erosions

The acute stage lasts up to three weeks then if the ulcer does not heal becomes subacute and reaches the chronic stage if it still persists in two months

Acute Ulcers or Hæmorrhagic Erosions are commonly multiple They vary in size from a pin head to an inch in diameter may occur irregularly distributed anywhere in the stomach but are commonest in the pyloric half They are shallow and rarely involve the muscular coat Œdema may occur round the ulcer and cause an apparently deep crater They tend to heal rapidly in two or three weeks

Subacute Ulcers are merely a temporary transition stage between the acute and the chronic *They are fewer in number than the acute (most of which* heal) and may be single The muscular coat shows commencing involvement and some basal inflammatory reaction is present

Chronic Gastric Ulcer—This is the type which is usually presented for X ray *examination*

They are usually single The following data have been compiled by *Hurst* and *Stewart*

(1) Single in 97 5 per cent of cases

(2) Position —

	Per cent
Lesser curve region	84
Pyloric canal	12
Cardia	1
Anterior wall	
Posterior wall	3

The lesser curve region includes those on the anterior and posterior walls close to the lesser curve

(3) Size —The average size in 186 cases they investigated was 16 × 10 mm According to the Mayo Clinic 94 per cent showed a diameter less than 2 5 cm

(4) Form of the Ulcer —This depends on the stage

When active the ulcer is deeply excavated sometimes *globular* and with thickened overhanging edges The surrounding mucosa is œdematous *When indolent* the thickening and œdema of the margin diminish but still overhang until *the healing stage* when the ulcer gradually assumes a conical shape

(5) Floor of the Ulcer —*When the muscular coat is breached granula*tion tissue and later fibrosis form a new floor most commonly in the thickened gastro hepatic omentum The pancreas forms the bed of the ulcer in 4 per cent of cases and the liver in 1 per cent When these structures form the bed the ulcer is as a rule shallower than when the gastro hepatic omentum forms the floor

(6) Adhesions of the Ulcer Bed —The peritoneum covering the floor of the ulcer responds to inflammatory irritation by a localised plastic peritonitis causing adhesions to neighbouring structures The adhesions may cause some deformity and by retraction of the lesser curve upwards and to the left contribute to an hour glass loculation

RADIOLOGICAL FEATURES OF GASTRIC ULCER

The X ray signs of gastric ulcer fall into two classes—direct and indirect There are many indirect signs of varying value There is only one direct sign, but it is virtually pathognomonic and will be considered first

THE DIRECT SIGN OF GASTRIC ULCER

This consists of the demonstration of the ulcer crater—the niche of *Haudek* In its most typical and most easily demonstrated form it consists of a protrusion of the barium shadow from the lesser curve This is at once evident when the stomach is filled with a contrast meal It is not necessary for the ulcer crater to be situated precisely on the lesser curve to be so visible It will be seen even if on the anterior or posterior wall if not more than an inch or so from the lesser curve if it be in an active stage as spasm and œdema bring it into profile Again rotation of the patient in the appropriate direction will show a crater in profile if it be masked in a true postero anterior view (Fig 31) As a preliminary however to this the most certain demonstration of an ulcer crater the relief pattern of the gastric mucosa should be studied by the white wash method of *Gilbert Scott* This frequently shows the ulcer crater filled and directs attention to it before filling the stomach completely—a procedure which in certain cases masks a posterior wall ulcer

Appearances of the Crater in the Mucosal Pattern Radiogram

The relief pattern is of particular value in the study of ulcers in sites where a profile view of the crater is difficult or impossible to obtain such as the *anterior or posterior wall and in or near the fundus* The ulcer crater visualised in such a radiogram will vary in its appearance according to its degree of activity Assuming that the crater is on the posterior wall and the radiogram taken with the patient supine there will be visible

(1) A Central Fleck the barium filled crater the *tache suspendue* of the French

(2) A Zone round this Devoid of Barium —This represents the œdematous mucosal lip of the crater The width of this zone forms an index of the activity of the ulcer or more precisely of the surrounding mucosal inflammation The wider this transparent zone the greater the œdema

(3) Finally a Corona of Mucosal Rugæ converging towards the crater The convergence again is an index of the chronicity of the ulcer The

convergence is *the result of cicatricial contracture round the crater* and is present only in ulcers which have reached the chronic stage (Figs 32 and 33)

Appearances of the Ulcer in the Filled Stomach

With the stomach filled with barium cream and the patient erect the ulcer

(a) (b)

Fig 31 —Posterior wall ulcer (a) Clearly visible in relief picture (b) Almost entirely hidden in postero-anterior view of the filled viscus

crater seen in profile may present a wide variety of appearances depending on its size depth and activity

ACTIVE CHRONIC ULCER —The crater filled with barium appears to be *deep and often with a rather narrower neck and a rolled-over edge* The depth may be so considerable that it appears almost certainly to have penetrated right through the gastric wall into the perigastric tissues (Fig 34) At operation the appearances are as a rule very different—a comparatively shallow

FIG. 32.—Posterior wall ulcer crater seen *en face*. Well marked rugal corona

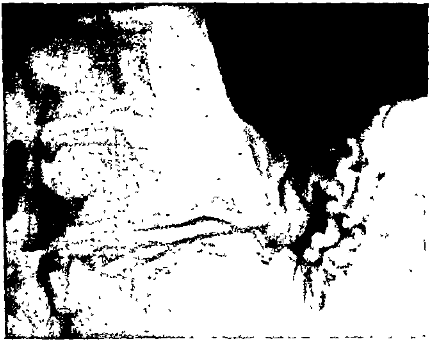


FIG. 33.—Posterior wall ulcer, showing rugal corona on compression.

ulcer, with no suspicion of penetration through into the perigastric tissue *Forsell* first suggested the explanation of this discrepancy

X ray examination usually takes place during or immediately after an active phase of the ulceration—is indeed often precipitated by an especially severe bout of dyspepsia and the stomach is therefore examined when its mucosa is catarrhal and œdematous round the ulcer

Operative interference on the other hand as a rule takes place after the

FIG 34 —Large active lesser curve ulcer with œdematous edges

patient has had some days or weeks of treatment with the result that the associated gastritis and œdema of the mucosa round the crater has subsided when the ulcer is inspected at operation (Figs 35 and 36)

It is then the œdema round the crater that is responsible for its depth and the degree of the œdema can frequently be determined with accuracy by visualising the normal line of the lesser curve It will then be seen that the deepest part of the crater lies on that line and that the pathological lesser curve sweeps well to the left in a blunt mound on the summit of which is the neck of the crater The estimation of the size of this mucosal hillock is of

Fig 3 — Slit or letter box ulcer crater on lesser curve The shape and absence of mucosal oedema indicate a healing stage

Fig 36 —Lesser curve ulcer crater

importance in judging the degree of *gastritis* and its healing under medical treatment

If as a result of the above factors the ulcer crater is very deep locular and with a narrow neck an appearance in the erect position results which was previously described as diagnostic of chronic perforation and formation of a perigastric cavity Three layers are then visible in the cavity—air fluid and barium—from above downwards The somewhat clumsy term accessory pocket has been *applied to this appearance* This lamination is also seen in true perigastric cavities resulting from chronic perforation They however tend to be larger and may not have the characteristic position of the former relative to the lesser curve (Fig 37)

FIG 37—Perforating ulcer of the lesser curve with formation of a perigastric cavity or accessory pocket Note the two levels separating air secretion and barium respectively

A fleck of barium very typically remains in the crater *after the stomach has largely* emptied and when the barium has sunk *well below the level* of the crater It remains in the crater because of the absence in the crater of secretory and peristaltic activity of the muscularis mucosæ These two factors tend to rid the normal mucosa of any coating of barium but the inert crater has not the power to do so Indeed the residue of barium is often exceptionally dense since the barium particles tend to settle and silt up the crater

HEALING CHRONIC ULCER—*As an ulcer heals changes in its X ray* appearance take place

(1) The œdema of its edge lessens *This makes the ulcer shallower* and widens its neck

(2) The ulcer begins to fill up from below

These two changes tend to give the healing ulcer a V shape the angle of the V widening as healing progresses Eventually if as a result of treatment the associated gastritis entirely clears up a shallow rounded crater is left It is at this stage that it is difficult to be certain radiographically whether an ulcer has healed or not The crater may be no more than a millimetre or so in depth

and any associated spasm of the greater curve disappeared Unless the ulcer crater be viewed tangentially to the barium filled stomach it may well be missed and an ulcer pronounced to be healed when in fact healing is not complete (Fig 38)

The above provides a pretty bone of contention between the protagonists of the medical and surgical methods of treatment of peptic ulcer and the search for a shallow ulcer must be very thorough *before it is safe to say that the lesion is* completely healed

Direct Sign of Ulcers in Special Sites

PYLORUS —For anatomical reasons pyloric ulcer *presents different radiographic features from those elsewhere* The ulcer being more or less enclosed in a muscular ring no mucosal œdema can develop and as a rule no deep crater is visible If a crater be seen at all in the pyloric canal it is usually small and shallow In other cases the niche may *be in the form of a spicule or a tiny* diverticulum If seen *en face* a rosette appearance (*la cocarde*) may be seen from the central fleck and the radiating plicæ More commonly some distortion only of the canal is visible and associated with it some deformity of the duodenal bulb This distortion is marked if the ulcer *crater extends into the duodenum as it not uncommonly does* In some cases there is an actual pylorospasm a condition which makes the demonstration of the ulcer very difficult (Fig 39)

FUNDUS —An ulcer in this rare site is difficult of direct demonstration It is most likely to be seen in a relief pattern radiogram prone or supine Its demonstration is largely a matter of chance

Fig 38 —Healing lesser curve ulcer taken at monthly intervals

and screen examination is necessary to determine the particular position in which the crater can best be seen if at all

CARDIA—This is another rare site The ulcer is usually situated just below the orifice and may be visible as a niche Not uncommonly there is a projection of the barium shadow in this region from a mucosal fold and it is

Fig 39—Two cases of pyloric ulceration

always difficult and may be impossible to differentiate between the two Again just below the cardia is the commonest site of a gastric diverticulum which may also be mistaken for an ulcer crater

INDIRECT SIGNS OF GASTRIC ULCER

Gastrospasm

This is the commonest indirect X ray sign of gastric ulcer

It is either circumscribed or regionary If the ulcer be on the lesser curve the most typical spasm is a localised notch on the greater curve opposite the ulcer This notch or incisura may be shallow or may extend almost to the lesser curve and produce a pure spastic hour glass stomach of the B type (Fig 40) While usually opposite the ulcer crater it is not invariably so and may occur either above or below it The latter is the commoner variation

Sometimes instead of a single notch there may be present a series of notches of varying depth The deepest is usually at the centre of the group and *those on either side gradually diminish in depth (Fig 41) Again there may be*

a series of small indentations of equal width spread along the greater curve Such incisuræ must be distinguished from two other conditions giving a somewhat similar appearance Thickening of the mucosal rugæ in a not too completely filled stomach is the one which most closely simulates it Indeed, *rugal thickening from chronic gastritis is a not uncommon accompaniment of* gastric ulcer and both a spastic incisura and notching from mucosal thickening

FIG 40 —Large lesser curve ulcer with spastic hour glass deformity Deformed duodenal bulb from old ulceration

may be present together in a case of ulcer of the lesser curve The notching of the greater curve by increase in the rugæ is a very common accompaniment of peptic ulcer anywhere it represents a reflex mucosal phenomenon and is aptly described by the Germans in the term *Zahnelung* The other cause of *indentation of the greater curve—extrinsic pressure from a gas filled splenic flexure—produces a coarser and less regular indentation*

In the so called organic hour glass contracture a large amount of the deformity is due to spasm Indeed in many of the cases of hour glass stomach

in which there are two completely separate loculi, with a long narrow channel of communication, the deformity may be entirely spastic. As a rule, however, these grosser forms of hour-glass contracture are partly organic and partly spastic. A feature of these contractures is the sagging of the upper pouch well below the level of the ulcer and communicating canal, due to the obliquity of the contracted muscle fibres. In contradistinction to this is the X-shaped hour-glass of scirrhous carcinoma.

FIG. 41.—Ulcer crater on the lesser curve with associated gastritis and gastrospasm.

In cases of pyloric or juxta-pyloric ulceration a regional spasm may occur of the pyloric antrum. It is usually associated with a pylorospasm and appears as a lack of filling of the antrum close to the pylorus. A rather longer spastic contracture of the pyloric antrum is commonly seen in *gastritis or ulcer following gastro-jejunostomy*.

INTRINSIC OR EXTRINSIC GASTROSPASM.—*Carman* held that these two types could be differentiated by administration of belladonna or atropine. His view was that if the spasm be intrinsic exhibition of atropine to full physiological effect would *not affect it*, while it would abolish a gastrospasm due to such causes as *duodenal* ulcer, biliary disease or chronic appendicitis. *Hurst* denies that atropine has this selective property. The test has fallen out of use now, because of its uncertainty and more particularly because with improved technique of recent years the direct demonstration of the lesion is more certain. In addition the procedure is unpleasant for the patient, as the drug has to be pushed to full pharmacological effect. Benzedrine sulphate mg. 10-30 is said to be effective in abolishing gastrospasm.

Abnormalities in Size, Tone, Peristalsis, and Rate of Emptying

At first sight changes in the above properties of the stomach show a bewildering variety and irregularity Any attempts to co ordinate them directly with the type of ulcer crater prove unsuccessful In one case a lesser curve ulcer is associated with hypertonus hyperperistalsis and rapid emptying and in another the reverse The same is true of the similar so called secondary signs of duodenal ulcer In reality they are not strictly signs of ulcer at all *Hurst* has pointed out that if the above changes be considered relatively to the pyloric function some order emerges from the chaotic variety He groups ulcers of the stomach as follows

(1) Gastric Ulcer with Normal Pyloric Function (ulcus simplex)

(2) Gastric Ulcer with Pyloric Achalasia —In this the initial opening of the pylorus is later than normal and the periodic relaxations are infrequent and relatively ineffective Relaxation can be assisted by palpatory pressure and a normal amount of the contrast medium forced into the duodenum *Hurst* describes pyloric achalasia as a reflex inhibition of relaxation resulting also from a remote abdominal lesion such as an appendicular or a biliary focus of irritation

(3) Gastric Ulcer with Pylorospasm —In this condition none of the meal can be forced through the pylorus The condition simulates pyloric obstruction in the early stages of the examination and later relaxes to allow the stomach to empty

(4) Gastric Ulcer with Pyloric Obstruction in which the pylorus fails to open normally at all

In the study of the pyloric function note must be made of any transparent contents already in the stomach when the opaque meal is given The barium meal usually divides such contents into two portions the smaller of which passes into the pyloric antrum and is trapped there as in a U tube The major portion floats up on top of the opaque meal in the gastric fundus The former lesser moiety must pass out of the pyloric antrum into the duodenum before the pyloric ring and duodenal bulb can be visualised This state of affairs must be distinguished from the above mentioned pyloric abnormalities and can be by noting in the pyloric antrum during a phase of relaxation the horizontal fluid level made by the contact of trapped fluid and opaque medium

Size and Tone of Stomach in Gastric Ulcer

(1) Ulcus Simplex —A simple ulcer without change in the pyloric function had no influence in gastric tone The presence of hypertonus or hypotonus depends on the habitus of the patient and not on the ulcer In actual practice hypotonia is very commonly present in cases of gastric ulcer—in 90 per cent according to *Kohler*—and hypertonus much less commonly

This *Hurst* explains by ascribing to the gastric habitus a determining

effect on the *site* of the ulcer Thus a pre-existing hypertonus tends to localise a peptic ulcer in the duodenum, while hypotonia tends to the development of the ulcer in the stomach *Hurst* regards this as an important factor in the localisation of the ulcer, particularly duodenal ulceration The writer is not convinced that this is true

(2) ULCER WITH PYLORIC ACHALASIA —This likewise has no effect on gastric size and tone

(3) ULCER WITH PYLOROSPASM —Increase in size and lessened tone result

(4) ULCER WITH PYLORIC OBSTRUCTION —The hypotonia is marked and develops into atony and marked gastric dilatation

Peristalsis in Gastric Ulcer

This again depends largely on the pyloric function and on the patient s habitus

In simple ulcer, or in one with associated pyloric achalasia, peristalsis is unaffected In one with pylorospasm peristalsis is increased at first and later diminished If the pylorus be obstructed, gross initial hyperperistalsis is the rule, the dilated stomach writhing with wide deep peristaltic waves In a *short time after ingestion of the meal this is replaced by aperistalsis and atony*

Rate of Gastric Evacuation in Gastric Ulcer

This will depend on the factors already considered, namely tone peristalsis, and pyloric function, but it is a very common feature in lesser curve ulcer to find a small six hour residue in the stomach This should be tested fasting The residue may be due to hypotonia, to pylorospasm or to pyloric stenosis In those cases in which it is due to hypotonia the stomach empties freely in the early stage of evacuation, but seems unable to rid itself of the residual pool of barium in its lower pole The persistence of the residue is postural in cause If the patient assumes the horizontal posture during the six hour period, complete gastric evacuation occurs in normal time When the gastric delay in evacuation is due to disturbance of the pyloric function, this will be apparent on screen examination immediately after the meal is taken when the pyloric disfunction will show itself

Localised Tenderness on Pressure

This is a sign on which stress used to be laid, but one which has ceased to be of importance since direct demonstration of the ulcer crater became the *desideratum* If there be persistent and localised tenderness on pressure over an ulcer crater, such tenderness is obviously an indirect sign of ulcer, but one which is of little importance in view of the visible crater itself In the absence of a crater or deformity, the sign is so uncertain as to be valueless It would, however, be of significance if found over a localised area in the lesser curve

with a corresponding incisura on the greater curve If a tender point be present, and *known to be due to an ulcer, its value is that it indicates an* active stage of the ulcerative process It is commonly held to be due to visceral tension in the ulcerated area produced by the palpating finger

This indirect sign becomes relatively more important in areas where it is difficult to demonstrate the ulcer crater—e g pyloric and gastro jejunal ulcers —*but it is a sign of no great certainty* Its localisation must be meticulous and its interpretation guarded

Frænkel's Sign, or "Peristaltic Jump"

This sign would be of importance if it could be demonstrated easily. It consists of an interruption of the peristaltic wave on the lesser curve by the ulcerated area The latter takes no part in the wave, which begins again on the distal side of the lesion It was shown first by *Frankel* in a rapid series of films by superimposition The sign is of greater importance in early carcinoma, or will be when advances in cineradiographic technique allow it to be easily and accurately demonstrated

Segmental Rigidity and Straightness of the Lesser Curve

Duval Roux, and *Beclère* lay stress on these as signs of ulcer somewhere in the stomach Peristaltic sinuosity is absent, according to these authors, for a variable length on either or both sides of a niche on the lesser curve It is a sign difficult to detect with certainty, and while, if it is seen, it should raise the suspicion of ulcer, by itself it can do no more diagnostically

CICATRICIAL SIGNS OF GASTRIC ULCER

These are three in number pyloric stenosis, organic hour glass contracture, and contracture of the gastro hepatic omentum

Pyloric Stenosis

Three stages can be made out in chronic pyloric stenosis from the scarring of an ulcer

First Stage Compensated —In this stage the stomach shows little or no dilatation, peristalsis is active but not excessively so, and evacuation takes place slowly but fairly efficiently In this stage it is usually possible to demonstrate the narrowed pyloric canal In order to do so, it is essential that the stomach be empty, as retained secretion and food make it impossible to fill the canal with barium

Second Stage of Failing Compensation —Considerable gastric dilatation is present Initial hyperperistalsis is excessive, and succeeded by atony as the gastric musculature tires

A pyloric stenosis which has reached a developed second stage presents very characteristic features on barium meal examination

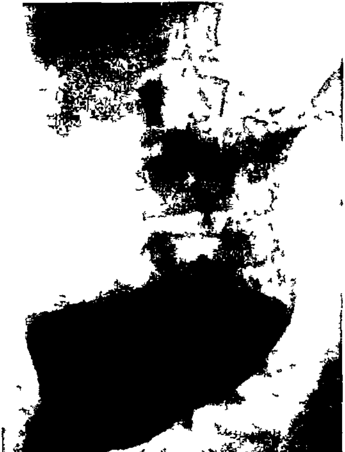


Fig 4 Pylor obstructo wil marked Hatat o an l lyo na Transparent contents occ py th preamula l o the lar n

Fig 43 Pyloric obstruction sho ng ll tat n a l tal l peristalsis of th st mach

On screen examination in the erect position the first abnormality that strikes the observer is the mode of filling of the stomach The barium is seen either to slide down the lesser curve to the lower pole or much more commonly to drop in round blobs through transparent fluid contents already in the stomach Even with careful preparation and withholding of food or liquid for hours before the examination the stomach will be found to contain quite

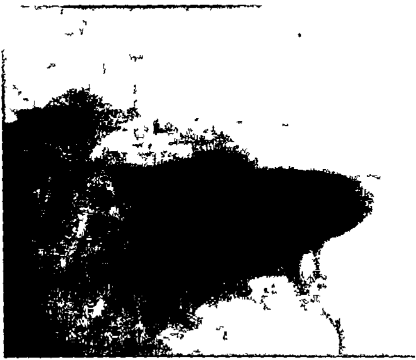


FIG 44 —Seven hour gastric residue in pyloric obstruction the wide pool of obstruction

a large amount of liquid (Fig 42) chiefly swallowed saliva and resting gastric juice

As soon as the stomach becomes partly filled vigorous hyperperistalsis sets in the waves being deep and wide A characteristic of them is that the lesser curve also shows deep peristaltic indentations equal in magnitude to those on the greater curve This large wave hyperperistalsis is seen only in pyloric obstruction (Fig 43) The large size is due to the gastric dilatation In non-obstructive hyperperistalsis the waves are smaller and more numerous

In this stage of stenosis it is not always possible to demonstrate the pyloric canal itself If possible at all the prone position is the best in which to show it In that position a narrow streak of barium may sometimes be seen in the stenosed passage

Fig. 42.—Pyloric obstruction with marked dilatation and hypotonia. Transparent contents occupy the part raised above the barium.

Fig. 43. Pyloric obstruction showing dilatation and initial hyperperistalsis of the stomach.

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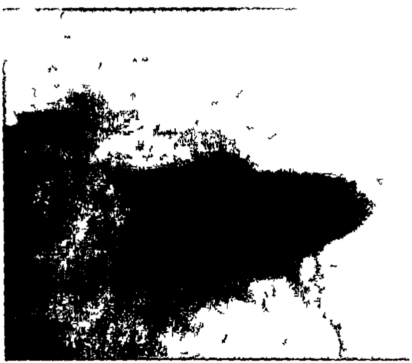

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After a variable but usually short time the gastric hyperperistalsis dies down and hypotonia sets in until the ingestion of a further meal excites vigorous peristalsis again In the hypotonic stage the stomach will show in the erect position a pool of barium at the lower pole topped by transparent fluid (Fig 44) It is characteristically wide and shallow as a result of the gastric dilatation In contradistinction to this the residue in simple non-obstructive hypotonia is deeper extends less from side to side and more nearly approximates to a *semicircular shape*

The final point in the diagnosis of pyloric stenosis is the amount of the residue and its duration So far as the duration is concerned a six or seven hour residue may result from simple ptosis and hypotonia pylorospasm or stenosis The size and shape of the residue may give a clue to the type If however there is a gastric residue at the twenty fourth hour the condition is almost certainly one of organic stenosis A twenty four residue is virtually *pathognomonic of considerable organic narrowing of the pylorus*

In milder degrees where there is a residue only to six to eight hours and doubt arises as to whether the delay is due to gastroptosis the postural test may be applied by instructing the patient to remain recumbent after taking the meal This will abolish the delay due to ptosis but will have little effect on that due to pyloric stenosis

THIRD STAGE COMPLETE ATONY of the stomach is approached Initial *peristalsis is not a marked feature while dilatation is* The *stenosis is so* marked as to cause almost complete obstruction and the stomach is emptied chiefly by vomiting Little can pass via the pylorus

In this stage there may be little or no twenty four hour gastric residue, as all the barium may have been vomited and enquiry should be made as to this factor in cases of gross pyloric stenosis

Differential Diagnosis —From the above it will be seen that pyloric stenosis or obstruction whatever its cause gives a typical clear-cut radiological picture in its various stages Its diagnosis is simple but the determination of the preci e cause is often difficult and may be impossible

There are however certain points which may help in the differential diagnosis between post ulcerative stenosis and the other types

(1) PYLOROSPASM —*This although not a stenosis may simulate it at first* view It can arise from many causes such as peptic ulcer anywhere in the stomach or duodenum cholecystitis pancreatic renal and appendicular lesions Stasis in the stomach may result but it is usually only an initial delay in emptying The hyperperistalsis dilatation and atony of the type described above are absent and the condition is inconstant A deciding point lies in the demonstration at some stage in the examination of a normal pyloric canal When the *pylorospasm is* associated with a pyloric or juxta pyloric inflammatory lesion it will usually be impossible at first sight to apportion the amount of the obstruction due to the spasm and

œdema, and that due to permanent scarring When there are clinical indications that the lesion is in the pylorus, it is worth while applying the therapeutic test, by placing the patient under a strict medical regime for some weeks What was previously a twenty four hour stasis may be reduced to a seven- to ten hour stasis, or the size of the twenty four hour residue may be diminished More accurate information as to the need for operation is then available

(2) STENOSIS AND OBSTRUCTION FROM TUMOURS —Carcinoma is nearly always the tumour responsible It may produce general gastric signs identical with those of simple stenosis The dilatation is not usually so great, but additional signs are often present

(*a*) The so called amputation of the pylorus The pylorus and prepyloric region are not visible at first This is followed by filling of

(*b*) The stenosed passage which may be narrow, tortuous, and constant in its form

(3) HYPERTROPHIC STENOSIS OF THE PYLORUS OF ADULTS —The characteristics of this rare condition are described later

Although the differential diagnosis may be difficult, an attempt to find the precise cause should always be made, for purposes of treatment A carcinoma is an urgency, while even if gastro jejunostomy is contemplated in simple obstruction some weeks of strict medical treatment is an obviously desirable preliminary to operation

Hour-glass Contracture of the Stomach

Used in its widest sense—that of a biloculation of the stomach—the term includes a variety of conditions The following list includes the majority of these , some require no further mention and others some detailed description

(1) WITHOUT ORGANIC STENOSIS

(*a*) *Physiological*, the result of marked hypotonia The appearance of this is characteristic , a gentle narrowing in the pars media Occasionally, in women with very thin waists, this narrowing may be quite abrupt in the greater curve

(*b*) *Physiological Cascade Stomach*

(*c*) *Due to extrinsic pressure* from tumours of the spleen, pancreas, left kidney, etc , and particularly from a gas filled colon In the last named type, particular note should be made of the gas filled colon rising in front of the liver This produces the most marked degree of this type of biloculation, and borders on the state described under chronic intermittent volvulus of the stomach

They all show distinguishing characteristics: their variability, their smooth contours and an intact gastric mucosa.

(*d*) *Pure Spastic Biloculation.*—This has already been described under the signs of gastric ulcer. It may also occur as a reflex spasm from biliary, appendicular and other remote abdominal lesions, and is said to occur in chronic *tobacco poisoning*.

Fig 45. Lesser curve ulcer with hour glass contracture

(2) With Organic Stenosis

Simple Cicatricial Hour glass Contracture.—The forms which simple organic hour *glass contracture* may take are many and varied, depending on the precise degree and site of the scarring, but most of these present certain common characteristics by which they can be distinguished *from the carcinomatous* variety (Figs. 45 and 46).

(*a*) The contracture is nearly always at the expense of the greater curve, and the isthmus is at the lesser curve—this gives the B shape so often referred to.

(*b*) The lower pole of the upper loculus is almost invariably considerably below the level of the isthmus.

(*c*) The isthmus is usually in the middle third of the stomach, and its point of origin frequently coincides with an active ulcer on the lesser curve. In other cases it may be a little below an active ulcer, having been caused by a healed ulcer below the active one (Fig. 47). The calibre of the stenosis varies greatly in different cases, and it is important to note the width seen in the radiograms, and also to observe the rate at which the *meal passes from the upper to the* lower loculus. In severe cases the lower loculus may not fill for half an hour, and there may occur stasis in the upper loculus up to twenty four hours

Delay of this order usually means considerable cicatricial stenosis a lesser degree can however be produced by spasm superadded on a biloculation with quite a wide isthmus This may be tested by subsequent examination after a few weeks of rigorous medical treatment The latter may relax the spasm and reveal the true degree of the organic narrowing Exhibition of benzedrine sulphate may help in the differentiations The length of the isthmus may be from ½ to 3 inches

Stasis may occur in the lower loculus depending on the pyloric function—either from pylorospasm or organic stenosis there It is of importance to estimate the mobility of the stenosed channel since adhesions to the liver or pancreas are common and add to the difficulty of a partial gastrectomy

The observer on meeting with a case of organic hour glass contracture should not rest content with its demonstration but should take all possible steps to show whether there is an active ulcer associated with it either on the lesser curve pylorus or duodenum since the presence of an active lesion may influence the choice between medical and surgical measures

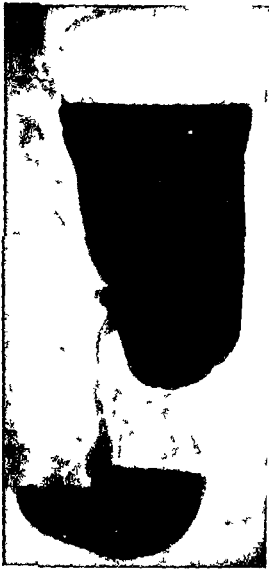


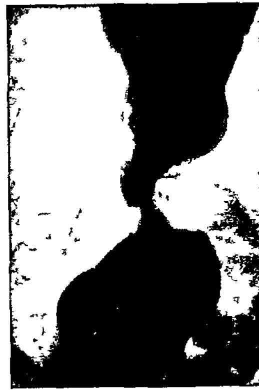
Fig 46 —Lesser curve ulcer at hour glass contracture

Malignant Organic Hour glass Contracture —This is described under the section on carcinoma of the stomach

Gastric Adhesions

Gastric adhesions may give radiological evidence of their existence by lessened mobility or displacement of the stomach or by distortion of its contour (Figs 48 and 49) but many of the simpler adhesions cause no visible changes

Fig 47 Less r c l er tl l ur gla o tract to nn e l a el after fill ng tl e s n a l
l o l r la cr r p c ely



F 48 I g lesser r o l r tl l our la s ontra ro a l a lt rence of p yl rus to le rater The full s c s per n posed on le r r

In general, it is wise to refrain from making such a diagnosis unless it is quite certain that there is no more serious explanation of the abnormal

FIG 49 —Lesser curve ulcer (→) hour glass contracture and deforming adhesions of the gastro hepatic omentum

appearance, such as ulcer of the lesser curve with contracture of the gastro hepatic omentum or gastric neoplasm It is said that extensive deforming adhesions can simulate the latter

CHAPTER VII

OTHER INFLAMMATORY LESIONS OF THE STOMACH

GASTRITIS

It will be seen from Chapter II that in attempting to assess the pathological significance of alteration in the form of the gastric rugæ those changes due to physiological and other factors must be discounted. This applies particularly in cases of gastritis in which the gastric rugæ are said to be thickened, rigid and tortuous. It is usually a matter of the greatest difficulty to say whether a given degree of rugosity of the gastric mucosa is physiological or pathological, particularly when the folds are usually seen only with the stomach relatively empty, and in the present state of our knowledge of the radiological appearance it is in most cases wise to refrain from such a diagnosis on a relief pattern of the semi-collapsed stomach alone. If, however, this apparent thickening and tortuosity are accompanied by a crenation of the greater curve when the stomach is filled with a barium cream containing no food, the diagnosis of gastritis receives more support. According to *Kadrnka's* observations the rugæ should then be small and should cause no indentation of the greater curve. This, of course, is upheld by the appearance in the normal stomach in the vast majority of examinations.

Fig. 0. Duodenal ulcer and marked associated gastritis.

Fig 51 —Healing ulcer with associated gastritis and radiating mucosal corona History of recent hæmatemesis

It should be borne in mind that the commonest cause of crenation of the greater curve is a *peptic ulcer* (Figs 50 and 51) and only after the most rigorous search has failed to disclose an ulcer crater should the milder lesion gastritis be diagnosed

Perianastomotic gastritis is a common sequela of gastrojejunostomy in those cases in which the acid curve remains high and the mucosal pattern may give some indication of this Again the same difficulty arises since the gastric mucosal pattern is frequently rather coarse in the normally functioning gastroenterostomy Other signs are therefore necessary, such as stomal ulcer or stenosis jejunitis tenderness over the stoma and the clinical symptom complex before such a case can safely be labelled as one of gastritis

ATROPHIC GASTRITIS

G I elde has given account of the appearances of the gastric mucosa in simple achylia gastrica and Addison s anæmia

The majority of the former cases showed no change from the normal In the few cases in which the usual hypertonus was replaced by atony a narrowing of the folds was noted and in one or two cases a thickening

In the atrophic gastritis of Addison s anæmia the mucous relief pattern was normal in most cases and in a few the rugæ were coarsened

No reliance can therefore be placed on the relief pattern in atrophic gastritis This may be deduced *a priori* from the pathological change The atrophy involves principally the epithelial layer, and the muscularis mucosæ and vessels of the submucosa which constitute the autoplastic mechanism are unaffected Probably such variable abnormalities which have been noted in these cases are not produced by the atrophy at all but by some other incidental factor

PLASTIC LINITIS

(*Syn* cirrhosis of the stomach , fibromatosis of the stomach leather bottle stomach)

History —First named cirrhosis of the stomach by *Andral* in 1845 it was described accurately by *Brinton* in 1859 It has been studied in detail by *Alexis Thomson*

Ætiology —There has been considerable difference of opinion regarding this Some cases presenting the clinical radiological and naked-eye pathological features of linitis plastica have turned out to be diffuse scirrhous carcinoma and syphilis can produce a similar macroscopic appearance Excluding these there remains a group which according to *Thomson* are due to infection spreading from an ulcer It is a disease of adult life

Pathology —The condition consists of a diffuse spreading fibrosis of the submucosa starting usually at the pyloric region The muscularis is involved in the fibrotic change to a less extent and the gastric capacity is diminished

Radiological Features —The diminished gastric capacity is immediately evident on screen examination The diminution takes place particularly at the pyloric end of the stomach and is less marked as the fundus is reached The stomach is relatively aperistaltic The pyloric canal involved in the fibrosis remains widely patent and the meal pours rapidly into the small intestine The appearance of the mucosal pattern is variable If the mucous membrane is relatively uninvolved in the fibrotic process the rugæ are rendered more prominent by the contraction of the gastric lumen If the mucosa is atrophic the rugæ gradually disappear

As in any case of marked diminution in the gastric capacity compensatory œsophageal dilatation may take place particularly if the pylorus be not gaping

The contour of the stomach shows a mild irregularity only depending on the distribution of the fibrosis

It will be seen that it is quite impossible to distinguish radiologically between the carcinomatous syphilitic and infective types of linitis plastica Even where the Wassermann reaction has excluded the specific form the carcinomatous issue remains in such doubt as to make laparotomy advisable in all cases where there is hope of a successful gastrectomy

SYPHILIS OF THE STOMACH

Incidence —Tertiary syphilitic lesions of the stomach congenital and acquired are extremely rare occurrences in England Only one authentic case (*McNee s*) has been published in this country It is reputed to be common in China and Russia *Easterbrook* gives an incidence in America of 0 3 per cent of 2 500 cases of gastric ulcer operated on at the Mayo Clinic

Pathology —The disease begins as an infiltration in the submucous tissue and may be diffuse or localised Ulceration and contracture soon supervene The ulcers are frequently multiple and associated with hyperplasia of the gastric wall The pyloric antrum is the commonest site of the condition

Radiological Features —In a condition with such protean morbid anatomy, the radiographic picture is bound to be varied *LeWald* has described the following types

(1) GENERALISED INFILTRATION producing a stomach markedly diminished in size with rapid emptying and compensatory œsophagectasia Peristalsis is diminished or absent The condition closely simulates linitis plastica and generalised scirrhous carcinoma

(2) THE DUMB BELL DEFORMITY resulting from fairly symmetrical infiltration and contracture of the pars media A large annular scirrhous carcinoma produces the same deformity and this type is usually diagnosed as such

(3) LOCALISED AREAS OF INFILTRATION AND ULCERATION in the stomach This type simulates a fungus carcinoma

(4) LOCALISED PYLORIC AND PREPYLORIC INFILTRATION which tends early to produce stenosis It produces a filling defect very similar to that of a scirrhous carcinoma

The differential diagnosis between gastric syphilis and the other lesions which it may simulate cannot be made on the radiographic evidence Due attention must be paid to signs of syphilis congenital or acquired elsewhere and to the Wassermann reaction A final proof is the result of vigorous antisyphilitic treatment In a number of cases reported by *LeWald restitutio ad integrum* has radiographically speaking taken place after some months of treatment This obviously is too lengthy a procedure to adopt as a diagnostic measure with a carcinoma as the probable alternative diagnosis unless the lesion is so advanced as to be inoperable if it is malignant

TUBERCULOSIS OF THE STOMACH

This is always secondary to tuberculosis elsewhere most often pulmonary next in frequency intestinal It is usually a terminal stage in the course of a tuberculous illness and as such rarely reaches an X ray department *Broders* has collected 306 recorded cases and has grouped them into two types

(1) **Hypertrophic** (20 per cent) —This type usually occurs in the pyloric region and produces large filling defects very similar to those of an encephaloid carcinoma

(2) Ulcerative (80 per cent)—The ulcer is usually on the lesser curve *There are no distinguishing radiological features between it and simple ulcer* except that it tends to be larger

Reliance must thus be placed on the presence of tuberculosis elsewhere in *the body in the differential diagnosis of gastric tuberculosis*

ACTINOMYCOSIS OF THE STOMACH

This is of extreme rarity *Schinz* has recorded a case in which the gastric lumen was considerably narrowed and irregular in contour It simulated a rather ragged scirrhous carcinoma *Behring* describes a case of actinomycosis of the pylorus and adjacent duodenum which gave a radiographic picture of pyloric obstruction He reviews the literature and notes eight cases of which only three were primary in the stomach and one in the duodenum In one of the gastric cases the radiographic diagnosis was lesser curve ulcer and in the other two carcinoma

On considering the macroscopic pathology of the disease one would expect to find irregular filling defects rigidity of the gastric wall and diminution of the gastric capacity all of which would render a radiographic diagnosis of carcinoma inevitable

GASTRIC FISTULÆ

External Fistulæ

These may result from trauma—wounds or operations—or from pathological lesions such as subacute perforation of a gastric ulcer

They are best demonstrated radiographically by an injection of an opaque cream or lipiodol into the opening If the track be tortuous stereoscopy is of help in demonstrating its ramifications In order to prevent the contrast medium from leaking away externally the sinus should be sealed with adhesive plaster immediately after the injection In other cases it may be necessary to keep up pressure from the injecting syringe in order to ensure that the track is filled when the radiogram is taken A rubber tipped urethral syringe is an advantage here

By these means the track of the fistula can as a rule be traced down to the viscus with which it communicates In these fistulæ a satisfactory view may sometimes be obtained by taking a tangential view after filling the stomach with barium cream and the fistula from the outer opening if necessary

Internal Fistulæ

These may be the result of trauma (usually operative) or disease The colon is the other viscus most commonly involved rarely the gall bladder and other viscera

Gastro-colic Fistula is usually the result of carcinoma most often of the stomach and much less frequently of the colon Less commonly it is the result of simple ulcer tuberculosis of the colon or following gastro-jejunostomy

Gastro jejuno colic Fistula —While gastro jejunostomy may be the cause of gastro colic fistula the end result is more commonly a jejuno-colic

ula from the perforation of a jejunal ulcer into the transverse colon This with the already existing gastro jejunostomy forms a gastro jejuno colic fistula

Although gastro colic and gastro jejuno colic fistulæ usually give a history that is almost diagnostic the diagnosis is made clear by X ray examination Either a barium meal or a barium enema may demonstrate the lesion but the latter method is quicker and much more certain Sometimes the enema shows the state of affairs clearly after the barium meal has failed to do so

The barium enema appearances are quite characteristic The colon fills normally with the enema as far as the transverse colon Then depending on the type the enema floods the jejunum and stomach or the stomach alone As the patient is lying supine while the enema is being run in the gastric fundus fills up in a way that leaves no doubt as to the nature of the condition The presence or absence of jejunal flooding determines whether the fistula is gastro jejuno colic or gastro colic

It is of importance to be able to indicate the cause of the fistula The detection of a colonic or a gastric filling defect indicates carcinoma as a cause Here the barium meal is of value so far as the stomach is concerned The history of gastro jejunostomy and the jejunal flooding indicate the cause in the post-operative type

The barium meal appearances are also usually quite characteristic As the stomach fills the barium pours out into the colon or jejunum and thence colon Bearing in mind the fact that the actual fistulous connection in a gastro jejuno colic fistula may not be visible and that the jejunum may fill very quickly in the normal it is evident that with a meal examination one must look for an immediate filling of the transverse colon as a proof of the presence of a fistula and in this connection it should be remembered that an opaque meal may reach the transverse colon *per vias naturales* in the space of an hour or less Stress must therefore be laid on the *immediate* colonic filling This does not always happen In a case observed by the writer the colonic filling was delayed for an hour It was not until a barium enema was given that the presence of a gastro jejuno colic fistula was conclusively proved Barium in the stomach after the administration of a barium enema can mean nothing else than a fistulous track between colon and stomach

CHOLECYSTO GASTRIC FISTULA —The only other internal gastric fistula deserving of notice is the cholecysto gastric It results from the ulceration of a gall stone through the adherent walls of the two viscera in question or from perforation of a gastric ulcer simple or malignant Barium emulsion readily passes from the stomach through the fistula into the gall bladder and thence may pass into the bile ducts If the bile ducts are outlined the nature of the condition is clearly evident If however only the gall bladder is filled it might be mistaken for a duodenal diverticulum of the acquired type A lateral view serves to distinguish between the two The gall bladder lies anteriorly in the abdomen while a duodenal diverticulum lies on the posterior abdominal wall

CHAPTER VIII

NEOPLASMS OF THE STOMACH

BENIGN TUMOURS OF THE STOMACH

Types —These are all exceedingly rare Pathologically they fall into three *groups—connective tissue tumours glandular tumours and cysts*

CONNECTIVE TISSUE TUMOURS —*Fibromata* may be either polypoid or *intramural more commonly the former in the pyloric region Myomata and fibro myomata* form the commonest type in this group Upwards of sixty cases have been reported They may be pedunculated either subserous or submucous or intramural *Angiomata* and *lipomata* may also occur the latter tending to form large intragastric pedunculated tumours

GLANDULAR TUMOURS —Under this heading are the solitary and the multiple pedunculated adenomata The *solitary adenomata* form the commonest type of gastric polypi occur usually in the pyloric region and may reach the size of an apple

The *multiple adenomata* (*syn* multiple mucous polypi gastric polyposis) are spread uniformly over the gastric mucosa and rarely reach a larger size than cherries They are generally found in conjunction with chronic gastritis

CYSTS —These are rare and result from injury degeneration of tumours implantation of hydatids or retention cysts in chronic gastritis

The hydatid cysts may reach large dimensions

Radiographic Appearances —It is unlikely that a subserous pedunculated tumour could be demonstrated satisfactorily in a radiogram The intragastric polypoid tumours are on the other hand readily demonstrable with careful technique

If the tumour be single and small it will be completely obliterated by filling the stomach with an opaque cream Only by employing the mucosal pattern *technique can this type be rendered visible*

If it be single and large it will show in a mucosal relief picture and usually produces a filling defect in the filled stomach This filling defect tends to be round and mobile

Multiple polypi produce characteristic filling defects—numerous small rounded gaps in the barium shadow scattered throughout the stomach If these are not visible in the filled lower pole of the stomach gentle pressure partly to empty the lower pole of barium will bring them into view

The e intragastric benign tumours can be shown with great clarity by air

insufflation of the stomach especially if this be combined with previous administration of colloidal barium or diagnothorine to outline the mucosa. The round marble shadows of the polypi in gastric polyposis show clear outlines,

(a) (b)

FIG. 52.—Pedunculated adenoma of the prepyloric region of the stomach. On screen examination the tumour produced a rounded mobile filling-defect and could be displaced through the pylorus into the duodenum and back again. (a) Shows the tumour in the pyloric antrum, and (b) in the duodenum.

in marked contrast to the disorganised irregularity of outline of an intragastric encephaloid carcinoma.

A *juxta pyloric polypoid tumour* may pass through the pylorus and cause a rounded mobile filling-defect in the bulb (Fig. 52). A further stage of the same process is *a gastro duodenal intussusception*.

CARCINOMA OF THE STOMACH

The stomach is the commonest site in the body for carcinoma to occur It is a disease of distressing frequency and the insidious nature of its onset *increases the importance of any method of investigation that will lead to* earlier recognition of the condition Radical treatment is feasible only in the earlier stage of the disease, and the earliest stages are quite latent clinically Radiology affords probably the most reliable method of demonstrating carcinoma of the stomach In the advanced case the radiographic picture is virtually conclusive

In the early stages the X ray method is not quite so conclusive as in the later but still it affords the most accurate method at our disposal for the early diagnosis of gastric carcinoma and by the time such a lesion has begun to give any clinical symptoms it is demonstrable by careful X ray examination

Ætiology

AGE —Carcinoma of the stomach may be met with at any age but is commonest between 40 and 60

SEX —Men are affected more commonly than women in a proportion of about 3 to 1

PREVIOUS SIMPLE GASTRIC ULCER —Much controversy has ranged round this question but such authorities as *C H Mayo Moynihan Sherren* and *Pauchet* hold that old gastric ulcer active or healed is a definite ætiological factor

Pathology

Primary carcinoma of the stomach may be composed of either spheroidal or columnar cells Either type may undergo colloid degeneration Depending on the amount of stroma present the growth is described as ' scirrhous , or medullary, encephaloid or fungous

The spheroidal celled type is twice as common as the columnar and is the usual type of malignant ulcer

The columnar type is commonest in the pyloric region frequently in the form of a fungoid growth

Either type may infiltrate the whole organ giving rise to one form of ' leather bottle stomach According to *Sherren* the spheroidal celled variety causes a diminution in the size of the leather bottle stomach while in the columnar celled variety the gastric lumen is not diminished

Site

In 90 per cent the growth is in the pyloric half of the stomach

It is located on the lesser curve in about 75 per cent and then in descending order of frequency on the posterior wall the pylorus the greater curve and the cardia

This distribution is in agreement with the view that gastric ulcer is a predisposing factor, being very similar to the distribution of the latter

Cancer of the stomach commences in the deeper layers of the mucosa, and tends to spread widely in the submucous layer The induration marks the limit of the infiltration of the mucosa but the submucous infiltration may extend for several centimetres beyond This is of importance in estimating the operability of a growth from the X ray appearances

Radiographic Classification

From a radiographic point of view carcinomata of the stomach fall into the following categories

Scirrhous Localised
Diffuse
Encephaloid
or *Fungous*
Malignant Ulcer

Localised Scirrhous Carcinoma

By the term " localised ' is meant a growth affecting portion of the stomach only, in contradistinction to the diffuse type which causes leather bottle stomach The characteristic X ray feature of this type is a contracture of the lumen, causing one kind of filling defect

The filling defect of this type of growth may assume a varied form, depending on the site and extent of the growth It may involve either curve alone, or both The narrowing of the lumen may be slight in extent or extreme It may involve a comparatively short segment of the gastric lumen, or a large portion The transition from healthy to infiltrated stomach may be gradual or abrupt, so far as the lumen is concerned As a rule an abrupt stepping back of the barium shadow occurs at this point A common type of filling defect is the *napkin ring* defect as though a napkin ring were constricting the gastric lumen (Fig 53) As would be expected, the closer to the pylorus, the narrower the constriction, and those at or close to the pylorus commonly cause obstruction

Although these defects are so varied in shape, they present certain common features

(1) They remain constant in shape Their particular configuration must remain essentially unchanged in a series of radiograms, allowing for slight variations due to the degree of gastric filling

(2) They are aperistaltic The peristaltic waves can frequently be traced down to the upper limit of the filling defect, there to disappear

(3) They display a lessened flexibility when tested by radioscopic palpation

(4) In contradistinction to the encephaloid type these scirrhous filling defects do not typically present any spiky or jagged outline

(5) A palpable thickening or mass may be present

In the majority of these cases there is no doubt as to the nature of the condition but very early cases may show no conclusive feature and doubt may arise in some of the pyloric growths

In the very early malignant infiltrations the only sign may be the *peristaltic jump* described by *Fraenkel* and then only if the infiltration be on the lesser

FIG 53 Annular scirrhous carcinoma of the pyloric antrum producing the napkin ring deformity

or greater curve If on the posterior wall it would be undetectable radiologically in the very early stages If on the greater curve it would be more obvious because of the interference with peristalsis

The mucosal relief pattern is considerably altered by a scirrhous infiltration the normal rugæ stopping short at the edge of the lesion

Definite changes in the pyloric function take place in scirrhous carcinoma of the stomach *If the growth be not causing mechanical obstruction the pylorus tends to be widely patent*— the gaping pylorus of cancer In a

certain small percentage of cases this is due to an infiltration of the pyl canal transforming it into an open rigid tube Usually however such infiltration causes stenosis and the commoner type of gaping pylorus is fu tional and associated with the achylia which is the rule in carcinoma of stomach in any situation

Commonly the contrast meal is seen to pour in a steady stream through rigid gastric lumen into the duodenum The lack of peristaltic activity in extensive scirrhous growth in no way alters this rapid transit Indeed

Fig 54 —Carcinoma of the pars media producing X shaped hour glass contracture

more extensive the infiltration the more marked is this feature reaching maximum in the leather bottle stomach

Carcinomatous Hour glass Stomach —This appearance results wher scirrhous carcinoma involves the pars media in an annular fashion Charact istically the hour glass is X shaped in contradistinction to the B hour glass simple ulceration (Fig 54) In the latter the contracture is solely at the expe of the greater curve In the X carcinomatous type both curves are invol in the contracture the lesser curve to a less degree than the greater In this ty of hour glass the stenosed communicating channel is usually visible in its entire and little or no overlapping of the upper loculus occurs The isthmus bei a filling defect shows the characteristics above described

Secondary œsophageal dilatation is not uncommon in cases of scirrh

carcinoma of the stomach where considerable diminution of the gastric lumen has taken place This dilatation is determined by the curtailed gastric capacity and not on gross obstruction to the gastric efflux

SCIRRHOUS CARCINOMA OF THE PYLORIC REGION —In this site the growth usually assumes an annular form and early causes obstruction (Fig 55) Considerable difficulty may be experienced in differentiating such a lesion from simple cicatricial stenosis or the hypertrophic pyloric stenosis of adults If the

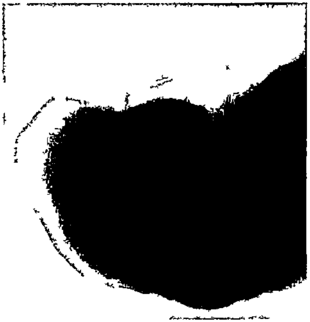


FIG —Obstructing annular scirrhous carcinoma of the pylorus

obstruction be marked it may be next to impossible to obtain a satisfactory view of the stenosed canal and one may have to be content with the demonstration of organic pyloric obstruction Careful preliminary preparation directed to ensuring that the stomach is quite empty prior to taking the opaque meal is of importance If the stomach already contain transparent secretion the ~~demonstration of the stenosed passage is rendered much more difficult~~ In carcinoma the stenosed passage is as a rule longer and more irregular than in simple stenosis The differential diagnosis between it and hypertrophic stenosis of adults is discussed in the section on the latter condition

Diffuse Scirrhous Carcinoma

This gives rise to one form of leather bottle stomach or linitis plastica The striking feature is the diminution in the size of the stomach It presents

an appearance similar to an exaggerated hypertonus tapering rapidly from the fundus to the pylorus The stomach is more or less horizontally disposed aperistaltic in the main and rapidly emptying Its contours will as a rule show mild irregularities and these persist in succeeding radiograms In other words there is a carcinomatous filling defect present but so extensive as to involve virtually the entire gastric contour (Fig 56) In these cases again the diminished capacity commonly results in œsophageal dilatation a point which

Fig 56 Scirrhous carcinoma of stomach leather bottle type

distinguishes them from total gastrospasm (Fig 57) In gastrospasm the contour is more regular and gastric evacuation less rapid

Carcinomatous linitis plastica shows a lessened flexibility to radioscopic palpation and a tendency to fixation in its position just as does the localised scirrhous lesion

The simple and syphilitic forms of generalised linitis plastica are identical in their radiographic appearances to those described above and cannot be differentiated radiologically from the malignant type

Medullary, Encephaloid or Fungous Carcinoma

In this type of neoplasm the filling defect the cardinal X ray diagnostic feature assumes a different type from that of the scirrhous growth Consideration of the macroscopic morbid anatomy will indicate the difference In the

fungous type there is in addition to the mucous and submucous infiltration the formation of irregular tumour masses which project into the gastric lumen. Again ulceration may take place in these tumour masses further to complicate the picture. In addition therefore to the irregularity caused by the infiltra-

Fig. [illegible] Diffuse scirrhous carcinoma of the stomach or malignant leather bottle stomach

tion of the gastric wall similar to but more irregular than that of a scirrhous infiltration *there will be seen gaps in the barium shadow due to the projection* of the tumour masses into the lumen of the stomach. These added defects are not inaptly called *finger print defects* as they are often rounded or oval and discrete not unlike finger print impressions (Figs. 58 and 59). The true

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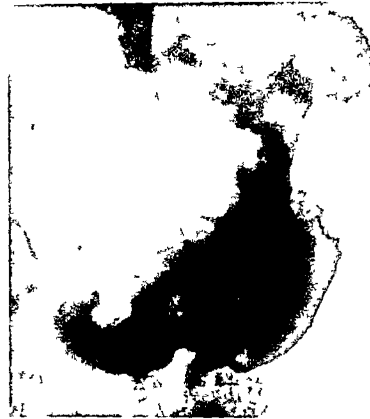

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FIG. 60 —Encephaloid carcinoma of the pars media showing the relief pattern

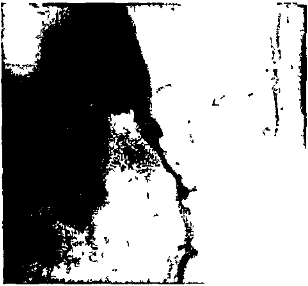


FIG. 61 —Carcinoma of the lower end of the œsophagus involving the cardia The shadow of the tumour projects into the fundal gas bubble (→)

finger print appearance does not always obtain In many cases there is merely a large irregular gap in the barium shadow, often with spiky, jagged edges These fungous filling-defects should be reasonably constant in a series of radiograms, allowing for variation in the amount of opaque cream in the stomach *Those on the contour of the gastric shadow* show least change those inside the gastric contour, *due to tumour masses on* the anterior or posterior wall may vary considerably according to how much the stomach is distended with the opaque cream The other radiographic signs, *namely the focal aperistalsis,* the rapid emptying the gaping pylorus, the lessened flexibility and mobility of the gastric wall, are all apparent in this type as in the scirrhous The presence of a palpable epigastric mass is more common in this type than in a scirrhous but it is a late feature in both. The œsophageal dilatation and X hour glass do not typically occur

The mucosal relief pattern in fungous carcinoma shows a marked and abrupt alteration *of the regular pattern* into a completely irregular one in the zone involved by the tumour *This destruction*

of the normal configuration is more marked than in the scirrhous type (Fig 60)

Fungous Carcinoma in Special Sites

(1) Anterior or Posterior Wall —An early papillomatous growth on the anterior or posterior wall may easily be rendered invisible by too complete filling of the stomach with barium cream It is important therefore to study the stomach when it contains a small amount of barium only when there is more chance of such small growths being visible in the mucosal relief pattern

(2) Fundus —Carcinoma of the fundus is usually of the encephaloid type

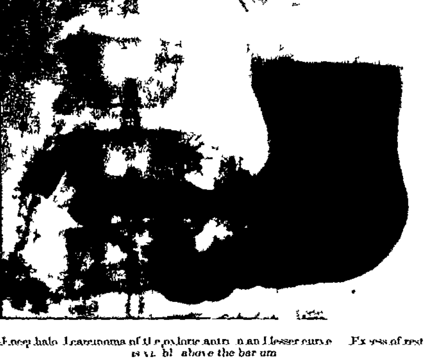


Fig 6 —Encephaloid carcinoma of the pyloric antrum and lesser curve Excess of resting juice is visible above the barium

and produces a filling-defect similar to elsewhere It is best demonstrated in the supine position

The majority of growths which involve the cardia are primarily œsophageal and have spread to the stomach round the cardia Obstruction there is the rule and radiographically a narrowed tortuous track is seen

Picchio has enumerated the signs of a fundal neoplasm as follows (Fig 61)

The gas bubble may show the tumour in relief contour Again the diaphragm outlined by lung above and gas in the fundus below may be unduly thick The tumour adds its quota to the thickness of this shadow

The filling of the fundus by a barium cream may be abnormal as the cream pours *from the cardia it may trickle* irregularly over the tumour mass

The mucosal pattern is interrupted by the tumour mass

Finally the filled fundus shows a filling defect

(3) Pyloric Antrum —Here obstruction frequently supervenes but the cause is more readily demonstrated radiographically than in the scirrhous type the jagged irregularity of the stenosed passage as a rule makes the diagnosis easy (Figs 62 and 63)

Carcinomatous Ulcer

Carcinoma developing in the edge of a simple peptic ulcer cannot be detected in the early stages

In a single examination several features will suggest that the ulcer has undergone malignant degeneration such as large size of the ulcer crater An ulcer crater with a diameter of 1 inch *or more should raise the suspicion* of malignancy Again the presence of a filling-defect immediately adjacent to the crater should raise suspicion Care must be taken not to mistake the gap caused by mucosal œdema for a carcinomatous filling-defect Occasionally some thickening may be evident *on* radioscopic palpation

Kirklin has emphasised by the adoption of the term meniscus an

Fig 63 Stages in the development of a carcinoma of the pyloric antrum (*a*) Early stage (*b*) Four months later (*c*) *Ten months* later The condition was diagnosed radiologically at the first examination but the patient refused operation

appearance seen in *many malignant ulcers of and near the lesser curve* The meniscus appearance consists in a translucent zone, 1 or 2 mm in width, separating the barium filled crater from the main barium mass filling the gastric lumen (Fig 64) He states that this is due to the growing malignant edge of the ulcer It is an appearance which should raise the suspicion of

Fig 64 —Malignant ulcer high up on the lesser curve showing the meniscus effect

malignancy, but the writer has observed it in several cases ultimately proved to be innocent In these the marginal œdema was the cause of the meniscus

If the case be under repeated radiological observation during medical treatment, failure on the part of the mucosal œdema to subside, and of the crater to shrink, would also raise the probability of malignancy. It should be emphasised that many of these malignant ulcers are very slow growing and

that the gastric acidity may be normal Exploration should be undertaken if there is any doubt, since these malignant ulcers are more amenable to surgical removal than most gastric carcinomata

The following table, adapted from Kirklin, indicates the main differential radiographic features in simple and malignant gastric ulcer

	Simple	Malignant
Size	Usually 2 cm or less	Usually more than 2 5 cm
Shape	Hemispherical and sharply defined	Conical or irregular poorly defined Meniscus effect common
Site	Usually on lesser curve distant from pylorus	Variable site but most commonly on lesser curve towards pylorus Those on the greater curve are always malignant
Rugæ	Converge Corona and halo effect if seen *en face*	Interrupted without convergence
Peristalsis	Tends to be active	Often diminished or absent
Pylorus	Spastic if any change from the normal	Tends to gape
Tenderness	Present	Absent
Therapeutic Test	Heals	Enlarges or remains stationary for a time

SARCOMA OF THE STOMACH

Sarcoma, it is said, accounts for 1 per cent of all gastric tumours It is virtually never diagnosed radiographically so closely does it simulate carcinoma in a radiogram

Clinical Features —*The age incidence for sarcoma of the stomach is rather* earlier than that of carcinoma beginning at 20–30, and occurring very rarely after 70 There may be few or no symptoms Vomiting occurs in about half of the cases A palpable epigastric tumour is common, more so than in carcinoma Hypochlorhydria and achlorhydria may occur *but less frequently* than in carcinoma Hæmorrhage and perforation may take place Pyloric stenosis is rare, and cachexia a late symptom *Kundrat's* sign—swelling of the lymph nodes at the base of the tongue—in the presence of a palpable *epigastric tumour is indicative of a lymphosarcoma*

Site of the Tumour —In 54 collected cases the distribution was as follows greater curve 18 pylorus 14, lesser curve 1 anterior wall 8 posterior wall 8 diffuse infiltration 4 cardia 1

Three types occur and each tends to present a different radiographic picture

(1) Round celled Sarcoma —This begins in the submucous tissue, and may be diffuse or localised forming a tumour mass which encroaches on *the gastric lumen This type most common in the pyloric half of the stomach* is usually mistaken for an encephaloid carcinoma or polypoid growth It forms 60 per cent of gastric sarcomata

(2) Spindle celled Sarcoma —This the next commonest type (36 per *cent), tends to form a pedunculated subserous mass It may become large*

enough to fill the abdomen, and be mistaken for an ovarian tumour Cystic degeneration is liable to occur In a barium meal this type will cause a local gastric deformity of the intrinsic type, and possibly a considerable general deformity and displacement from extrinsic pressure

(3) LYMPHOSARCOMA (*Syn* malignant lymphoma)—*These tumours tend to infiltrate the stomach widely, and to produce diffused thickening of its wall* Other portions of the alimentary canal, such as the ileum and cæcum, are frequently simultaneously involved The pyloric antrum is a favourite site, but the pylorus itself is not usually implicated, and obstruction is uncommon The growth may show nodular or polypoid excrescences

Radiological Features—These are very varied as may be gathered from the macroscopic pathology *Spitzenberger* has recorded a large nodular lymphosarcoma *springing from the fundus and infiltrating spleen, diaphragm,* and cardia *Pattison* records six *cases and states that ulceration is rare* One of his cases presented a niche deformity, while the others simulated carcinoma The radiographic features are those of filling defect, rigidity of the gastric wall and aperistalsis, but there is nothing in those features which serves to distinguish the lesion from a carcinoma, for which condition it is nearly always mistaken *Courtney Gage* has recently described what he considers to be a characteristic appearance in the submucous pedunculated myosarcomas of the stomach These tend to necrose at their centre and *produce a filling-defect like a tangerine in the middle of which is a deep* ulcer niche ' *Odqvist* has reported an exactly similar appearance in neurinoma of the stomach, a rare, usually benign tumour, poorly vascularised and tending to necrosis It is most commonly found on the greater curve

CHAPTER IX

MISCELLANEOUS GASTRIC CONDITIONS

CONGENITAL HYPERTROPHIC STENOSIS OF THE PYLORUS

ALTHOUGH THE history and clinical triad—propulsive vomiting visible peristalsis and palpable tumour—on which the diagnosis of this condition rests are so characteristic as to leave little doubt as to its nature X-ray examination forms a valuable check and becomes of prime importance when that triad is not complete

Ætiology—Two views are held as to the cause of this condition that the hypertrophy is a primary congenital overgrowth of muscle alternatively that reflex spasm is the cause of the hypertrophy It is a true hypertrophy of the circular fibre of the pyloric canal The hypertrophy stops abruptly at the duodenum but extends to some extent into the prepyloric portion of the stomach emerging gradually into the normal Males are affected more commonly than females in a preponderance of 4 to 1

Technique—The babes affected are ill wasted and enfeebled and all manipulation should be reduced to a minimum Especially should they be protected against cold during the examination The meal should consist of 2–3 oz of warm thin sweetened barium emulsion or a similar amount of warm milk containing barium This can usually be given in a feeding bottle but if this is not effective the meal must be given through a catheter The child is then laid on the X-ray couch intermittently screened for a short period to study the pyloric function and radiograms taken every half hour until the stomach is empty Note must be kept of any vomiting during the period of examination

Radiological Features—The appearances in the stomach after a contrast meal has been given depend on the duration of the condition

In very young infants there is little dilatation and peristalsis is active The cardinal sign according to *Meuwissen and Slooff* is a lengthened pyloric canal with sharp differentiation from the pyloric antrum As little passes through the pylorus and at infrequent intervals demonstration of this very valuable sign is difficult and may be impossible When seen the canal is not only lengthened but extremely narrow no more than the thickness of a needle By careful palpation it may be possible to determine the coincidence of the pyloric tumour with the pyloric end of the stomach or the pyloric canal if visualised

The time of gastric evacuation is usually greatly lengthened Compared

with the normal emptying rate of one to two hours the stomach may take four hours or more to evacuate its contents completely Some variation in this may result from vomiting This must be allowed for in attempting to estimate the severity of the stenosis from the degree of stasis According to *Strauss* if less than 70 per cent of the meal has passed out of the stomach in four hours the severity of the stenosis is such as to call for operative interference

If the condition has lasted for a month or two dilatation becomes evident *Hills* describes the X ray features at this stage as being dilatation of the stomach deep lively peristalsis and well marked stasis in addition to the stenosed passage The deep wide peristalsis is most marked immediately after taking the opaque cream and this is succeeded after a variable interval by atony

In the late stages the initial hyperperistalsis is less marked and of briefer duration while the atonic dilatation increases

CHRONIC HYPERTROPHIC STENOSIS OF THE PYLORUS IN ADULTS

F H Twining has given a full description of this condition from which paper the following account is largely taken The abnormality is a rare one In the Mayo Clinic eighty one cases were found in 60 000 examinations *Twining* records three cases

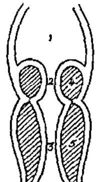


Fig 65 —1 Duodenal bulb 2 Pyloric canal 3 Antral lumen 4 Pyloric sphincter 5 Hypertrophied prepyloric circular muscle fibres

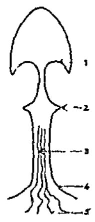


Fig 66 —The barium meal outline in hypertrophic stenosis of the pylorus in adults For Nos see text

Morbid Anatomy —The essential feature is *a hypertrophy of the circular muscle fibres in the last inch or so of the antrum pylori* This hypertrophy is prepyloric the pyloric sphincter is not involved to any great extent although it may show some degree of hypertrophy also

The causation is unknown

Radiological Features —A *consideration of the morbid anatomy will indicate the nature of the deformity which this condition produces* in the barium filled pyloric antrum Fig 65 represents a longitudinal section through the pyloric region and Fig 66 shows the cardinal appearances in a barium meal examination as follows

(1) The Pyloric Impression —The true pyloric sphincter usually slightly hypertrophied indents the base of the duodenal bulb This effect varies with the posture and pressure on the abdomen It may disappear in the erect position

(2) The Prepyloric Cleft —This is a sharp barium protrusion into a mucosal cleft between the true sphincter and the hypertrophied prepyloric

Fig. 67.—Chronic hypertrophic stenosis of the pylorus in an adult. Female, aged [illegible]. Attacks of indigestion since 18 years old, associated with worry. Fluoroscopy showed a hypertrophic, slightly palpable, contractile prepyloric segment. Gastric residue at [illegible] hours.

fibres. It may be mistaken for an ulcer niche, but classically appears on both sides of the pyloric lumen.

(3) The Antral Lumen.—This is considerably narrowed in its distal portion, $\frac{3}{8}$ of an inch or less. The length of the narrowed portion is from

1 to 2 inches It varies in calibre from time to time In spite of this it never relaxes to any extent

(4) THE PROXIMAL END OF THE STENOSED PASSAGE IS ROUND in contra distinction to that in a scirrhous carcinoma which tends to be jagged

(5) MUCOSAL PATTERN —*In the contracted canal the mucosal folds are fine* and shallow At the proximal entrance they are contorted and may hold barium rests tenaciously

Differential Diagnosis —These cases are nearly always mistaken for annular scirrhous carcinomata *Turning* diagnosed one of his three cases correctly *In considering the differential diagnosis the following points should be borne* in mind In this condition the canal shows contractility and fine mucosal folds There is no pyloric flooding or palpable tumour The antral extremity of the filling defect is smooth and rounded (Fig 67)

GASTRIC DIVERTICULA

Two types are described congenital and acquired **Congenital Diverticula** occur as a rule on the lesser curve near to the cardia Rarely they are lower down on the lesser curve *Konjetzny* has recorded one arising from the middle of the greater curve They consist of a mucosal protrusion between the folds *of the gastro hepatic omentum In size they vary from that of a green pea to* a cherry Cases have been reported in detail by *Hurst* and *Briggs* *L H Paul* has recorded six cases and states that the commonest site is on the posterior wall at the level of the cardia Those in this position are best demonstrated with the patient supine and rotated slightly to the left

RADIOLOGICAL FEATURES —*If seen in profile they present a rounded* regular outline with a neck of varying width and length They fill readily during a barium meal examination and if examined in the erect position tend to show double barium fluid and air levels (Fig 68) The diagnostic problem is to distinguish them from deep ulcer craters Several points are of importance *in this connection such as their regular rounded contours and the absence of* reflex spastic phenomena gastritis tenderness or local œdema of the mucosa around the neck of the diverticulum Careful estimation of the actual distance of the diverticulum from the line of the lesser curve may help In diverticulum it is appreciable and real in ulcer it is only apparent If the mucosal œdema be discounted the base of an ulcer crater is seen to be intra and not extra mural *Stasis tends to occur in diverticula and barium may be seen in* them long after the stomach is empty

A study of the mucosal relief pattern may be informative The classic appearance of the rugæ round an ulcer described under that section will be absent It may be possible to trace the mucosal folds right into the diverticulum

Acquired Diverticula —These are small tent like protrusions of the gastric wall resulting from the drag of adhesions They are very rare usually seen in connection with gastric ulceration and are usually mistaken for ulcer craters

FOREIGN BODIES IN THE ALIMENTARY CANAL

Opaque foreign bodies are instantly recognisable in a radiogram Transparent ones can be demonstrated only if they are of sufficient size to cause a filling-defect in a barium meal

Opaque Foreign Bodies

Of the many types of foreign bodies which may be found the following are common pins safety pins hairpins needles nails tacks coins, buttons etc

(a) (b)

Fig 68 —Gastric diverticulum high up on the lesser curve (a) Postero anterior view note the ostium seen end on. (b) Oblique view

Rounded objects such as coins and buttons, usually pass Irregular objects such as tooth plates give more trouble and may become impacted Nails and tacks pass as a rule but pins and needles especially the latter present a problem radiographically and therapeutically, from their tendency to penetrate the viscus in which they lie

TECHNIQUE —In every case in which it is suspected that a foreign body has been swallowed the pharynx œsophagus, *bronchi* and the whole abdomen and pelvis should be carefully surveyed fluoroscopically and *radiographically* Screen examination is not enough If that alone be used, the most dangerous type of foreign body—a pin or needle—may be overlooked The foreign body

having been located its subsequent career should be observed in daily radiograms until it is passed The stomach forms a common halting place Once past the pylorus the terminal ileum is the next then the cæcum and subsequently it may be found anywhere along the colon The gas normally present in the alimentary canal is usually enough to orientate the foreign body but failing this an opaque meal may be given

Transparent Foreign Bodies

Bodies such as fragments of bone pencils or bezoars require examination with a barium cream If the foreign body be large it may cause a filling defect when the stomach is filled with barium emulsion More commonly such a procedure would blot the foreign body out in the picture Small opaque bodies can occasionally be outlined if one mouthful only of the opaque emulsion be given and the gastric mucosa outlined The foreign body may be coated at the same time and its outlines so made visible

TRICHOBEZOAR —A hair ball in the stomach is a rare occurrence even rarer than before because of the modern fashion of short hair among women The size may be considerable—up to an almost complete cast of the stomach

RADIOLOGICAL FEATURES —A large one may be visible through gas in the fundus The upper end may be seen projecting into the gas bubble—an appearance which is quite characteristic If a barium meal be given the hair ball will become coated with barium and so be visible On filling the stomach completely with barium cream the hair ball forms a filling-defect which if large can hardly be mistaken for anything else Finally after the barium cream has passed out of the stomach the surface of the hair ball will be impregnated with barium and again show a very characteristic mottled blotched appearance

PERSIMMON BEZOAR —This bezoar is found occasionally in America It is formed by the accumulated fibres of the persimmon fruit and forms a fibre ball with X ray characteristics similar to those of the trichobezoar

THE DUODENAL TUBE represents a foreign body intentionally introduced and one whose position has to be checked radiographically The tube or terminal olive is clearly visible in a radiogram The olive is proved to be in the duodenum when the tube itself presents a regular reversed S curve The lower limit of the S represents the curve of the duodenum

ASCARIDES —*Dillenseger* has recorded a case in which an Ascaris lumbricoides was demonstrated radiographically in the ileum being rendered visible by impregnation with barium sulphate after the passage of a barium meal

DEFORMITY OF THE STOMACH FROM THE PRESSURE OF NEIGHBOURING ORGANS

Such an occurrence must always be borne in mind when confronted with a gross deformity of the stomach The organs which most commonly act in this

way are the liver spleen pancreas left kidney, and colon Abdominal tumours and marked scoliosis may also produce deformity of the gastric contour

These pressure deformities are infinitely variable, depending on the organ responsible

Liver —Enlargement of the liver displaces the stomach downwards and to the left, and tends to produce a flattening of its lesser curve and a displacement of the pyloric region behind the stomach (Figs 69 and 70) In these cases rotation of the patient into the right oblique view is necessary to view the pylorus and bulb

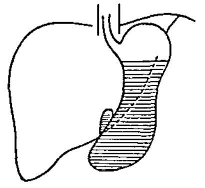


FIG 69 —Displacement of the stomach to the left by an enlarged liver

Spleen —The gastric fundus and greater curve are compressed and displaced to the right in moderate enlargement of this organ In extreme enlargement the whole stomach is displaced to the right The spleen in a case of perisplenitis may adhere to the gastric fundus and produce a rigid flattening of its left contour

Pancreas —Carcinoma of the head of the pancreas produces a characteristic stretching of the pyloric region and duodenal circle The duodenal arc may be considerably widened and its lumen reduced to a streak The pyloric antrum and pylorus may share in this process and at the same time be displaced upwards

Carcinoma or other tumour of the body of the pancreas tends to cause an extrinsic central or marginal filling defect in the body of the stomach near its isthmus In the erect position the gastric lumen is comparatively flattened from before backwards at the level of the pancreatic shelf and a tumour mass projecting forwards readily presses the posterior gastric wall forwards against the anterior The filling defect so produced is typically exogastric It has no clear cut margins and is readily made to disappear radioscopically by palpatory pressure on the lower pole of the stomach A lateral view may show the actual forward projection of the tumour Twining's method—a lateral radiogram taken of the barium filled stomach with the patient lying supine—is the best method of showing this

Left Kidney —Only if it is grossly enlarged does the kidney displace the stomach The displacement is forwards upwards and to the right (Fig 70) The right kidney if very large may displace the stomach to the left (Fig 71)

The Pregnant Uterus, large Ovarian Cysts, and other large abdominal tumours tend to raise flatten and rotate the stomach so that its greater curve looks forwards (Fig 72)

Gross Scoliosis, with the concavity in the left dorsal region as in the diagram causes elevation of the left dome and ballooning of the fundus (Fig 73)

(a) (b)

Fig. 70 Deformity of stomach [illegible] pressure of extrinsic tumour (a) Left renal tumour (b) Hepatic tumour (lateral view)

Fig 71 —Displacement of the stomach to the left by a large right hydronephrosis

Colon —The position of the transverse colon and splenic flexure relative to the stomach and their mesenteric attachments account for the various gastric deformities which follow gaseous distension and displacement of the former These deformities are very varied and range from mild indentation to complete volvulus of the stomach The milder changes are associated with simple colonic gaseous distension the more severe with distension plus displacement

SIMPLE INDENTATION FROM COLONIC BALLOONING —The commonest are those produced on the greater curve of the stomach by gas distended haustral pouches Almost as common are the indentations of the fundus from distension of the splenic flexure As the flexure distends it fights so to speak with the gastric fundus

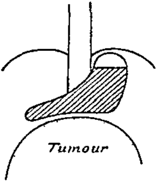


Fig 72 —Upward displacement of the stomach by a large ovarian tumour (or pregnant uterus)

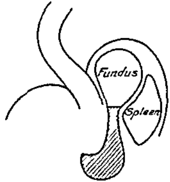


Fig 73 —Deformity of the stomach resulting from a gross scoliosis

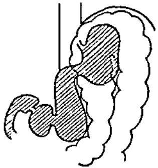


Fig 74 Biloculation of the stomach from gaseous distension of the left colon

for possession of the left cupola of the diaphragm; if it succeeds, the gastric fundus becomes small, compressed and displaced downwards to the midline.

Increasing distension of the flexure commonly implicates the distal portion of the transverse colon, and this may produce an appearance of biloculation of the stomach. This biloculation, if marked, may simulate a cascade stomach, but differs from the true physiological type in that the lower loculus is displaced to the midline (Fig. 74).

Fig. 75.—Volvulus of the stomach on its cardio-pyloric axis.

Deformities associated with Distension and Displacement of the Colon.—A characteristic displacement is that in which the transverse colon travels upwards in front of the stomach and not uncommonly still farther upwards between the anterior surface of the liver and the diaphragm, the so-called *falciform colon* or *anterior hepato-diaphragmatic interposition*. When this occurs the greater curve of the stomach is dragged upwards by the transverse mesocolon in front of the lesser curve and lies at an upper level. This constitutes the so-called *volvulus of the stomach on its cardio-pyloric axis* (Figs. 75 and 76). The lesser curve and pylorus remain in approximately their normal positions. Again, the hepatic flexure and proximal transverse colon may distort the stomach by passing up behind the liver to the right of the coronary ligament—a posterior hepato-diaphragmatic interposition.

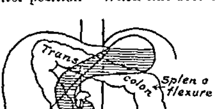
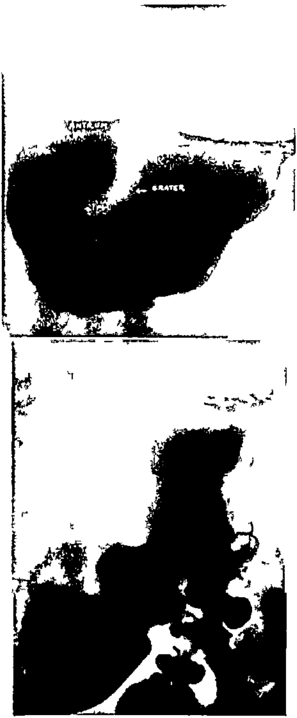


Fig. 76.—Chronic volvulus of the stomach on its cardio-pyloric axis from anterior hepato-diaphragmatic interposition.

It is convenient to mention here the other forms of gastric volvulus which can occur. One, *an acute type*, is associated with œsophageal obstruction from torsion of the fundus. Another, the *volvulus on the transverse axis*, presents a striking X-ray picture (Figs. 77 and 78). In this variety the stomach folds itself on a coronal axis and the antrum swings upwards in front of the body of the stomach to reach



the left cupola near the cardia. Antrum and fundus thus lie close together, the former in front. From it the pylorus points downwards to the left of the spine. The condition is best examined erect in the postero-anterior, left oblique and lateral views. Two barium fluid levels are evident in fundus and antrum and two corresponding air pockets.

This volvulus can take place only if the duodenum is long and has lax attachments or an actual mesentery. The ætiology is unknown. In the case of the author's shown in Fig. 77 there had been present a large ulcer of the lesser curve, nearly healed at the time of examination. The actual volvulus was accompanied by very severe epigastric pain radiating back between the shoulders. The essential feature of all the above gastric deformities due to the colon is their evanescent quality.

PATHOLOGICAL AERO-PHAGY

The swallowing of excessive quantities of air is a habit which may be distressing to the patient and still more to his or her companions. There are two types.

FIG. 77.—*Above.* Volvulus of the stomach on its transverse axis and lesser curve ulcer. *Below.* Same case re-examined on the following day showing the volvulus reduced.

In the simpler type air is swallowed in excess with each mouthful and the gas bubble in the stomach balloons out. This presses the left dome upwards and causes a feeling of discomfort and distension in the epigastrium. It is relieved by eructation, a procedure which the patient may find difficult to achieve. If eructation cannot be achieved, the gas must be got rid of via the intestines, and so tends to cause flatulent distension.

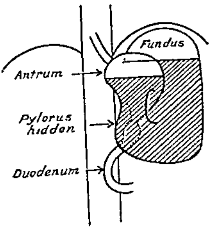


FIG. 8.—Volvulus of the stomach on its transverse axis

The more severe type is found chiefly in neurotic women, and is usually accomplished with much noise and fuss. A large quantity of air is noisily swallowed and distends the gastric fundus. It is soon got rid of by belching. At times the intake and ejection of the air is so rapid that it has no time to reach the stomach—the so called œsophago aerophagy. This is often repeated a number of times in rapid succession, and the general behaviour of the patient leaves no doubt as to its hysterical nature.

BORBORYGMI

This may be an embarrassing complaint for those of a sensitive disposition. The casual rumble may occur anywhere in the stomach or intestine, and requires no further mention. The repetitive type follows the respiratory rhythm and occurs in the stomach or splenic flexure. Both are due to diaphragmatic movement. In the gastric type the noise is due to air being driven to and fro through the collapsed isthmus between the fundus and body of the stomach. It therefore occurs particularly in subjects with a hypotonic stomach. When the splenic flexure is filled with gas a similar process may occur.

X ray examination may give an indication as to the site in which borborygmi occur in a particular case, by revealing excess of gas in either position.

RUMINATION OR MERYCISM

According to *Barclay* this habit is very rare in man, and is sometimes hereditary. The writer had the opportunity of observing a case fluoroscopically. In this case food could be brought up into the mouth immediately after meals, and this also occurred involuntarily. The act was quite different from that of vomiting. It was quiet, and unaccompanied by any violent muscular activity or distress. The barium cream was seen to well quickly up the œsophagus to the back of the throat, and then as quickly to descend into the stomach. The reflex appeared to be allied to that of eructation, and is doubtless an exaggeration of the phenomenon of water brash.

CHAPTER X

THE NORMAL DUODENUM

ANATOMY

THE DUODENUM the shortest widest and most fixed portion of the small intestine extends from the pylorus to the duodeno jejunal flexure It is about twelve fingerbreadths (10 inches) in length—hence its name—and describes a horseshoe curve It is arbitrarily divided for descriptive purposes into four parts—superior descending transverse and ascending Its course is as follows From the pylorus the superior portion passes upwards backwards and usually with an inclination to the right beneath the quadrate lobe of the liver to the neck of the gall bladder

It then bends sharply downwards into the descending portion along the right margin of the head of the pancreas to about the level of the upper border of the body of the fourth lumbar vertebra

It now bends to the left across the vertebral column forming the transverse portion then upwards on the left side of the vertebral column as the ascending portion and terminates at the duodeno jejunal flexure at the level of the second lumbar vertebra

Certain anatomical relationships are of clinical and radiological importance

FIRST OR SUPERIOR PORTION —This is variable in position inclination and level possessing as it does a short mesentery at its pyloric end Its long axis depends on the type of stomach In the hypertonic type it tends to run *backwards* to the right and slightly upwards In the hypotonic type it runs *upwards* backwards and with sometimes a slight inclination to the left Above it is the quadrate lobe of the liver The gall bladder lies in close apposition to its upper and right surface The head and neck of the pancreas lie below it and behind it are the gastro-duodenal artery the common bile duct and the portal vein This portion of the duodenum is completely covered by peritoneum except for a small triangular area posteriorly near the neck of the gall bladder At this area the common bile duct may occasionally indent the bulb and cause a vertical linear filling defect when compression is used

THE SECOND OR DESCENDING PORTION is covered by peritoneum in front only above and below the transverse colon Its most important relationships are the head of the pancreas the duct of Wirsung and the common bile duct all on the inner side The two latter traverse the duodenal wall obliquely and open together into the ampulla of Vater on the medial wall about the middle of this portion

THE THIRD OR TRANSVERSE PORTION curves across the spine, great vessels and diaphragmatic crura to the left of the vertebral column It is concave upwards It is covered anteriorly by peritoneum except near the midline, where it is crossed by the superior mesenteric vessels Above it lies the head of the pancreas

THE FOURTH OR ASCENDING PORTION ascends on the left of the aorta for about an inch or so and then terminates at the level of the second lumbar vertebra by turning abruptly forwards and downwards to become the jejunum It is covered with peritoneum anteriorly, and is supported at the flexure by the musculus suspensorius duodeni of *Treitz*

Such are the classic anatomical position and relationships of the duodenum Radiology proves them to be more variable than previously supposed, particularly the first and second portions

The important clinical relationships are those of the first portion of the stomach and gall bladder the second portion to the bile duct, the third portion to the superior mesenteric vessels and the whole duodenal curve to the pancreatic head, which it encircles almost completely

Structure —The duodenum possesses an incomplete serous coat and complete longitudinal and circular muscular layers The mucosa varies according to the part of the duodenum The first 2 inches—that portion which forms the duodenal bulb or cap—is devoid of valvulæ conniventes The remainder of the duodenum exhibits the valvulæ to a well marked degree These are circularly disposed reduplications of the mucous membrane, and, unlike the gastric mucosal folds, are permanent and not obliterated by duodenal distension This disparity in the mucous membrane in the first and the remaining parts accounts in part for the difference in the radiographic appearance between the duodenal bulb and the remainder of the duodenum

TECHNIQUE

The duodenum must be studied fluoroscopically and in a series of radiograms, the former being in part a preliminary to the latter Fluoroscopy is necessary not only to study the duodenum in active function but also to determine the position in which it may best be radiographed

Posture —The erect position should be used in routine work The majority of duodenal bulbs are best demonstrated in this position The prone and supine positions should be tried if the erect fails to allow a satisfactory demonstration Of the two latter the prone is more likely to present a satisfactorily filled cap than the supine

Plane —Screen examination is also of importance to determine the exact plane in which the bulb should be radiographed Usually an antero posterior view is satisfactory, but at times in this the second portion of the duodenum lies directly behind the bulb, with resulting confusion of the shadows of both

Slight rotation of the patient serves to the right or left to separate the two shadows In marked hypersthenia the right or first oblique view is necessary to show the duodenal bulb unmasked by the pyloric antrum Two oblique views are often necessary to demonstrate the crater of a duodenal ulcer in two planes

Pressure—Frequently it is necessary to maintain pressure on the abdomen during an exposure for two purposes in the main

In the hypotonic individual pressure over the lower gastric pole is required in order to fill the cap satisfactorily Again pressure over the cap is necessary in order to study its relief mucosal pattern A transparent lamb's wool pad such as is described in the section on the technique for the stomach pressed against the appropriate area of the abdomen by the screen and cassette carrier forms the simplest means of compression Of the mechanical compressors Berg's is the most satisfactory for the study of the duodenal mucosa

Opaque Medium—Whatever difference of opinion there may be as to the most satisfactory vehicle for the barium sulphate in gastric examinations there is no doubt at all that a plain emulsion containing no food is the most satisfactory for duodenal investigations The presence of food slows the rate of gastric evacuation and makes it a difficult and lengthy process to obtain a view of the duodenal bulb The bismuth salts are to be avoided for the same reason

NORMAL RADIOLOGICAL APPEARANCES

The duodenum can be studied only when filled with a contrast medium On screen examination when the stomach is filled with a barium cream succeeding peristaltic waves are seen to sweep towards the pylorus and after a variable number of abortive waves the pylorus opens and a small quantity of the cream is shot upwards into the duodenal bulb The first bolus may not be large enough to fill the bulb fully but usually after two or three similar peristaltic waves enough is ejected into the duodenum to distend it completely The bulb retains its contents for a few seconds at most and then by a contractile wave passes the bolus on into the villous portion of the duodenum (i e the portion possessing plicæ circulares)

The barium cream passes through the duodenum with considerable rapidity and is normally considerably subdivided by the plicæ circulares of the mucosa

The First Portion of the Duodenum

This is by far the most important part of the duodenum from an X ray point of view as it is the seat of duodenal ulceration

The first portion consists of the bulbus duodeni (Fig 79) or duodenal cap and a variable amount of feathery duodenum—i e duodenum supplied with

valvulæ conniventes This is a point of importance The normal bulb should be uniform and regular the normal duodenum beyond the bulb should be feathery The cap may therefore be surmounted by a feathery portion in a radiogram

The duodenal bulb presents a wide variety of normal appearances both as to

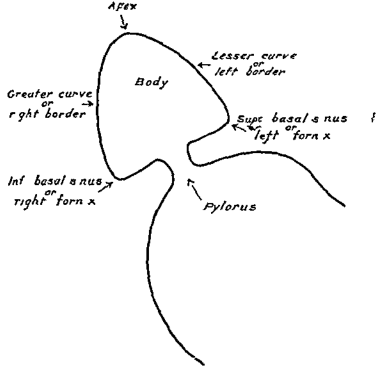


FIG 79 —Diagram of the normal pylorus and duodenal bulb

shape size and position Its shape has been compared with many similes such as acorn hazel nut ace of spades triangle beehive hemisphere etc The acorn with its base downwards is as good a simile as any This is the form which the duodenal bulb most typically assumes when it is full Fig 80 after *Schinz* shows the various normal types

Features of this the standard cap are the regularly curved right and left borders and the concave base The latter is also regular in its curve and is joined to the lateral margins by blunt angles or fornices The concavity of the base is due to the bulge of the pyloric sphincter muscle and is increased in hypertrophy of the sphincter The pyloric canal should join the base of the cap at its middle (Figs 81–85)

The cap outline should be regular until a point near its apex where it is surmounted by the feathery shadow caused by the valvulæ conniventes which begin at this point

Variations in the radiographic appearance of the normal duodenal bulb may be due to

(a) The habitus of the patient
(b) The degree of filling
(c) The posture of the patient.

(a) Habitus of the Patient —The *hypersthenic* individual possesses a short squat cap, the long axis of which may be nearly horizontal and backward

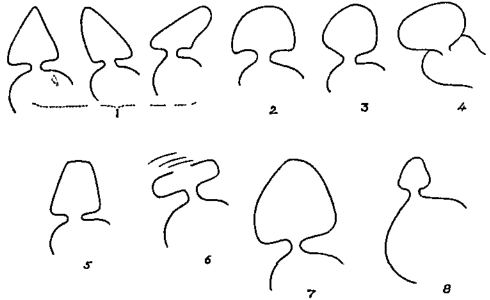


Fig 80 —Types of normal duodenal bulb 1 Triangular or peaked hat type 2 Dome shaped 3 Globular 4 Bulbous 5 Truncated sugar cone 6 Hammer head shape of incomplete filling 7 Megabulbus or justo major 8 Microbulbus or justo minor

inclined to some extent In the postero anterior view the cap may be seen end on, and the lower half thereof may be hidden by the pyloric antrum On turning the patient into the first oblique position, the pylorus and cap are seen unmasked by the stomach

In the *orthotonic* subject, the pyloric antrum is below the pyloric level and *the pylorus and bulb are seen in their entirety in the erect position* The bulb in this type is rather longer than it is broad, and a short feathery plume may be seen at its apex The inclination of the long axis is either upwards or upwards and slightly to the right, and only slightly backwards

In the *hypotonic* type the bulb is long and rather narrow It points directly upwards, or upwards and to the left Quite a large portion of feathery duodenum may surmount it

(b) The Degree of Filling of the cap will, of course, profoundly alter its X ray appearance This must be observed very carefully, as it is the commonest

cause of erroneous diagnosis of duodenal ulcer The irregularity due to incomplete filling is usually of a recognisable type Either a small pool in one or both of the fornices or extending right across the base or if the tone in the bulb be well maintained an outline of the mucosal pattern is visible This last is becoming of increasing importance and a recognition of the normal folds of mucosa in a contracted bulb is essential in the determination of a barium filled ulcer crater

FIG 81 —Normal bulb of the peaked hat type

The commonest arrangement is that of longitudinal folds continuous with those of the pyloric canal (Fig 82) These are not permanent but are obliterated by full distension of the bulb Occasionally they assume a criss cross or honeycomb pattern and in others a radiating outline from a central barium mass A distinctive feature of the normal mucosal rugæ in the bulb is their flexibility and elasticity They can be temporarily deformed and obliterated by pressure in contrast to their comparative rigidity in duodenitis

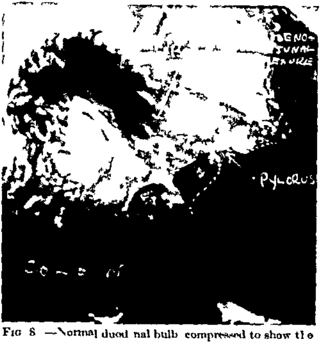


FIG 82 —Normal duodenal bulb compressed to show the mucous pattern

(c) THE POSTURE OF THE PATIENT has a considerable influence on the X ray appearance of the bulb Its long axis becomes more horizontal when the patient reclines and frequently its base is hidden by the overlying pyloric antrum This occurs particularly in hyposthenic individuals in whom the erect position is

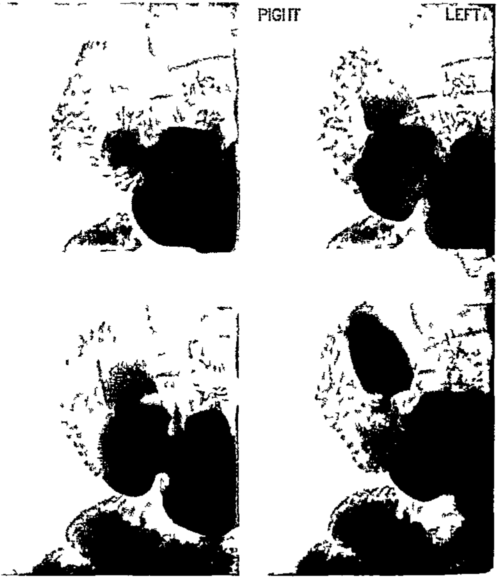


Fig. 53. Serial radiograms of the normal duodenal cycle

the more satisfactory in which to demonstrate the cap. In the erect posture a bubble of gas is occasionally trapped in the apex of the bulb. It is of no significance except that it must not be mistaken for a bubble in a deep ulcer crater or diverticulum.

The Duodenum Distal to the Bulb

The second, third and fourth portions of the duodenum show no radiographic demarcation but are merged into a more or less regular loop. As a

Fig 84.—Normal duodenum. Serial showing the cycle of filling

rule there is a sufficient change in direction between the first or superior portion and the remainder to determine the limits of each, but even here the curve may be too regular to allow of this

On observing an opaque bolus pass through the duodenum, the cap is seen

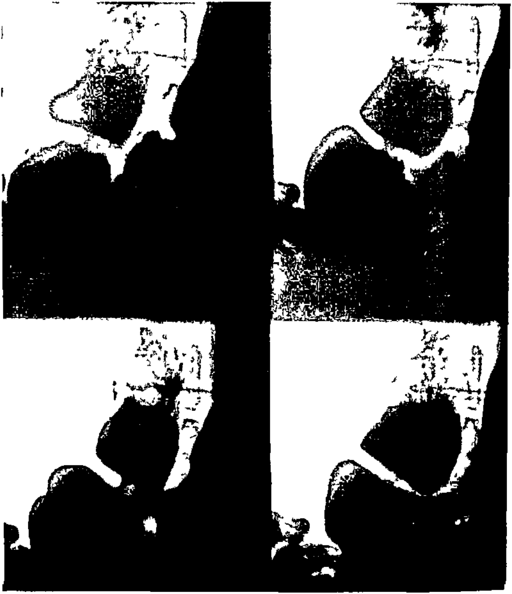


FIG 8 —Serial radiogram of a normal duodenal bulb

first to fill On the bulb contracting a stream of barium is seen to sweep round the duodenum into the jejunum in a remarkably fine state of subdivision A radiogram taken with a sufficiently short exposure will show this appearance in detail It is unusual to see a solid mass of barium in the normal duodenum beyond the bulb unless with very free gastric evacuation This

curious effect is produced by the valvulæ conniventes in a way not completely understood The mucosal pattern in the third portion may be flattened and longitudinally disposed where the superior mesenteric vessels cross the gut This appearance is exaggerated in arterio mesenteric ileus

AMPULLA OF VATER —In a small percentage of cases this fills with a barium cream and is visible as a small rounded shadow the size of a green pea close to the inner border of the second portion of the duodenum Its filling does not appear to have any clinical significance except that it may simulate a duodenal diverticulum It is unusual to find a rest retained in the ampulla after the stomach and duodenum are empty doubtless because the biliary and pancreatic secretions wash it out

DUODENO JEJUNAL FLEXURE —This forms a fairly acute angle in the hyposthenic individual and often just a gentle bend in the hypersthenic It shows no sphincteric action In the hypotonic the opaque cream may show slight hesitation before passing this flexure but hypotonia alone rarely causes any serious duodenal stasis

CHAPTER XI

DUODENAL ULCER AND OTHER INFLAMMATORY LESIONS

CLINICAL FEATURES

THE DUODENUM is much the commonest site of peptic ulcer duodenal ulcer being several times as common as gastric The causation and morbid anatomy are similar to those of gastric ulcer Thus they fall into two categories—acute erosions and chronic ulcers

Duodenal ulcer may be met with at any age but in the main it is a disease of adult life In children the condition is very rare and if present is usually in the form of an acute erosion The greatest age incidence is between 30 and 50 years Males are more often attacked than females in a ratio according to *Sherren* of 4 to 1 There is an association between duodenal ulcer and chronic appendicitis the latter standing in a causal relationship to the former

Situation —Over 95 per cent of duodenal ulcers are situate in the first inch of the duodenum According to *Clairmont* the commonest site is on the anterior wall next in order of frequency the posterior wall Sometimes two are present opposite one another the so called kissing ulcers

Perforation —This may be acute or chronic In the former the contents of the duodenum flood the abdomen In the latter the perforation is walled off by adhesions of a nearby viscus and a localised periduodenal cavity or accessory pocket is formed

RADIOLOGICAL FEATURES

The X ray *signs of duodenal ulcer may be grouped as follows*

(*a*) The visualised ulcer crater

(*b*) Adjacent inflammatory spastic and cicatricial changes in the bulb

(*c*) Secondary disturbances in the stomach

The Visualised Ulcer Crater

This is the one cardinal and pathognomonic sign of duodenal ulcer All *other signs are susceptible in occasional instances to other explanations*

Barclay first drew attention to the persistent fleck as a sign of duodenal ulcer Years were to elapse before the occasional recognition of a barium residue in an ulcer crater in the duodenum was elaborated by him and his pupils in England and by *Akerlund* in Stockholm, into a systematic demonstration of the ulcer crater in the majority of cases but to *Barclay* is due the credit of introducing the direct sign in the diagnosis of this condition

Although in the majority of cases the duodenal bulb shows a deformity in part due to other factors that due to the ulcer itself is of primary importance and a careful attempt must be made to demonstrate it in every case (Figs 86-89) *Berg* in recent years has stressed the importance of this and the technique

Fig 86 —Duodenal ulcer on anterior wall *en face* and *en profile* Note the mucosal corona brought into view by compression

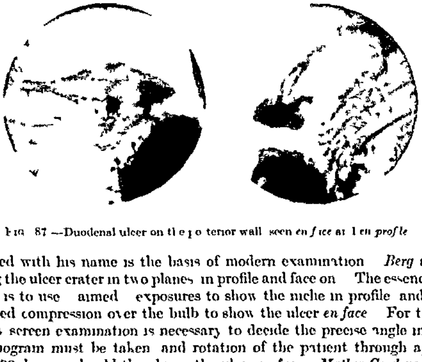


Fig 87 —Duodenal ulcer on the posterior wall seen *en face* and *en profile*

associated with his name is the basis of modern examination *Berg* aims at showing the ulcer crater in two planes in profile and face on The essence of his method is to use aimed exposures to show the niche in profile and to use graduated compression over the bulb to show the ulcer *en face* For the profile view screen examination is necessary to decide the precise angle in which the radiogram must be taken and rotation of the patient through approximately 90 degrees should then bring the ulcer *en face* *Mather Cordiner* points out that as the majority of ulcers of the bulb are on the antero lateral and

postero medial surfaces, the profile niche is usually best seen in the left anterior oblique position, and the *en face* in the right anterior oblique

The *en face* ulcer will be invisible in a well filled bulb, and *Berg* uses his "graduated compression" over the bulb to flatten it, partially empty it, and so bring the relief pattern of the duodenal mucosa into relief

This technique finds its particular value where spasm œdema and scarring of the bulb are all present in slight degree or not at all In such cases an anterior or posterior wall ulcer might be entirely obscured in a well filled cap, unless carefully sought for in this manner

An ulcer crater seen face on may show a different appearance, depending on the degree of pressure used the depth of the ulcer, and the amount of œdema round it Thus a deep crater, with little compression, may show a diverticular opacity with a fluid level and gas above A medium crater with surrounding

(a) (b) (c)

FIG 88 —Three views of a duodenal bulb (a) Postero anterior with compression one ulcer crater visible (b) With patient slightly rotated two are now visible (superimposed in the first view) (c) Lateral showing ulcer craters on anterior and posterior walls (kissing ulcers) The pylorus is marked X

œdema and considerable pressure produces the 'rosette' appearance (*la cocarde* of the French) that of a round central opacity and a surrounding translucent zone A shallow crater with little or no œdema, tends to show a star shadow , a central fleck with a radiating corona of mucosal plicæ *Forssell* has emphasised this radiation of the plicæ as a sign of a contracting ulcer

This demonstration of the ulcer crater in two planes profile and end on is a counsel of perfection unattainable in some cases Often in the obese hypersthenic subject whose duodenum is placed high under the costal arch and is not susceptible to radioscopic compression the *en face* picture is not feasible Again in such subjects the bulb may be hidden behind the pyloric antrum, and only one unobscured view be possible—one which may or may not be the correct one for the profile view of the ulcer In other cases the other factors may distort the bulb so grossly that the Berg technique is either unnecessary or ineffective Indeed most ulcers of the duodenum present a bulb deformity

due in part to other factors In some the crater is evident, in others the distortion is so gross that it is impossible to be certain what is ulcer crater either *en face* or in profile, and what is a crevice of normal mucosa thrown into prominence by the surrounding deformity

In such cases it is of first importance to establish one point regarding the deformity, whether or not it is constant Since an essential feature of bulbar

FIG 81—*Above* Right and left oblique views of the duodenal bulb taken without compression *Below* The same views taken with compression and showing a duodenal ulcer in its two planes

deformity due to ulcer is its constancy the importance of taking a considerable series of radiograms is obvious

Some variation in the appearance must result from the varying degree of distension as the bulb fills and empties, but discounting this the deformity must remain substantially the same in type and disposition if it is to have any significance

Adjacent Changes in the Bulb

These factors which produce superadded deformity in the bulb—mucosal oedema, muscular spasm, cicatricial contracture, and peritoneal adhesion—all

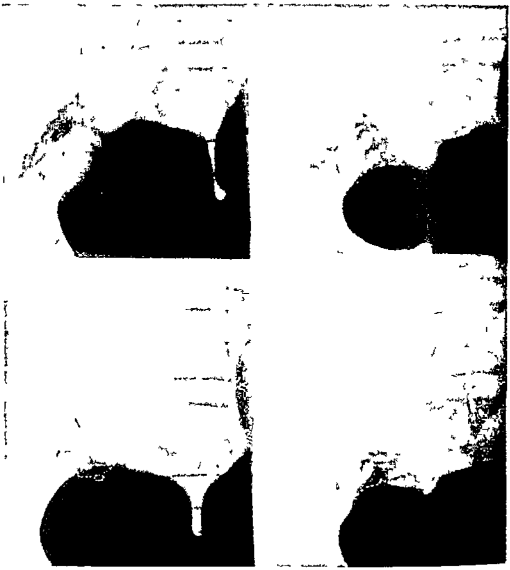


Fig. 90.—Serial radiograms of a duodenal ulcer producing general bulb deformity of the "pine tree" or "coral branch" type.

tend to encroach on the duodenal lumen. Œdema tends to produce a rounded inward bulge, spasm a sharper indentation, and scarring may assume any form. Periduodenal adhesions may produce contracture or "tenting."

By the varying intervention of these five factors—ulcer crater, œdema, spasm, scarring and adhesions—an almost infinite variety of bulb deformities may be produced, but they tend to fall into several groups.

Fig. 91.—Serial radiogram showing general bulb deformity from duodenal ulcer

(1) General Bulb Deformity.—The great majority of ulcers fall into this group. Of the many metaphors used to describe this type, the terms "coral branch," "shamrock" or "pine tree" deformities are the most commonly applicable (Figs. 90–94). In these deformities the actual crater can fre-

Fig. 3 Serial radiograms of a stenosing duodenal ulcer

quently be distinguished and beside it the spastic and œdematous elements Scarring can only be determined after repeated observation during a course of successful medical treatment It cannot be separated from the other two or its

presence definitely determined at one initial examination, unless there are indications of obstructive stasis in the stomach Then scarring sufficient to produce obstruction can be inferred

(2) NICHE DEFORMITY —This type, already described above consists of a protrusion of the barium filled crater seen in profile It is relatively uncommon alone

(3) AN INCISURA DEFORMITY *may be seen in a radiogram and usually means* the presence of an ulcer A careful search, after the manner of Berg should be made in such a case to demonstrate the actual crater

(4) The ÅKERLUND DEFORMITY a combination of niche and incisura is a

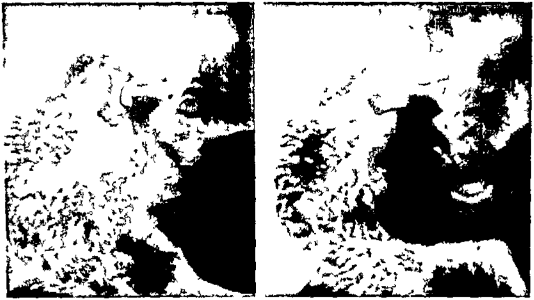


FIG 93 —Duodenal ulcer two phases of filling

very typical appearance with the niche on the lesser curve (left border) and the incisura on the right border It does not occur frequently (Fig 95)

(5) *DEFORMITY OF THE BULB ASSOCIATED WITH DISTORTION OF PYLORIC* CANAL —This occurs typically when the ulcer spreads from the duodenum into the pylorus The base of the cap is of necessity deformed at least on one side by such an ulcer The pyloric canal is commonly eccentric relative to the *bulb in such cases*

(6) RETRACTION (ÅKERLUND) —*Åkerlund* has described a change in the bulbar contour in the region of the ulcer crater to which the above term has been applied It consists of a loss of convexity or actual concavity of the *contour of the cap on either side of an ulcer seen in profile He attributed this* to muscular retraction round the crater, but *Berg's* explanation—that of mucosal œdema round it—is the more probable

(7) THE SMALL STENOSED BULB.—Marked scarring associated with ulceration may produce an irregular microbulbus. Associated with this there is not infrequently a dilated pouch formed by the base of the bulb (usually the right fornix thereof). This type was first described by *Akerlund* and the dilated pouch has been called the "prestenotic diverticulum" (Fig. 96).

(8) DEFORMITY FROM PENETRATING ULCER: THE ACCESSORY POCKET.—An "accessory pocket" results when an ulcer perforates the duodenal wall and forms a localised periduodenal cavity. It is an uncommon occurrence and may persist as one type of secondary duodenal diverticulum. In the erect position it typically displays, after a barium meal has been given, the three layers already described in connection with gastric ulceration—gas, fluid and barium from above downwards. It must be distinguished from a supra-ampullary primary duodenal diverticulum, the only other condition which can simulate it. *In the latter the cap outline is normal, while with a penetrating* ulcer there are certain characteristics in the radiographic appearances to which *Mather Cordiner* has drawn attention, as follows.

When an ulcer has penetrated into a neighbouring organ—e.g. liver or pancreas—the cap loses its mobility. If the pancreas is involved, the posterior wall of the duodenum is drawn out into a peak or tent when put on the stretch. A diverticular crater may surmount this. Occasionally the normal longitudinal mucosal folds can be seen bending abruptly into the funnel-shaped channel to the crater. This dragging on the bulb tends to foreshorten it. The above signs may be tabulated thus:

(1) Fixation of bulb.
(2) V-shaped deformity with niche.
(3) Accessory pocket or diverticulum.
(4) Divergence of rugæ into the funnel-shaped channel.
(5) Foreshortening of bulb.

Secondary Disturbances in the Stomach

The most frequently observed of these is *hyperperistalsis*. It is held by some that this is evidence merely of a predisposing habitus, but in many cases it is too marked in degree to be accounted for on that ground, and must be explained as a reflex from the duodenal focus of irritation. This hyperperistalsis, occurring with a patent pylorus, results in rapid gastric evacuation.

Increase in the thickness of the gastric rugæ, especially along the greater curve, is a common occurrence. This is shown in the filled gastric lumen by crenation of the greater curve and by widening of the rugæ in the relief pattern. It is commonly ascribed to an associated gastritis, but may also be a reflex phenomenon on the part of the gastric mucosa and muscularis mucosæ.

Hypertonus is frequently seen, but unlike hyperperistalsis can be accounted for as merely an indication of the habitus of the patient. Duodenal ulcera-

FIG 94 —Ulcer crater posterior wall of bulb seen *en face* with mucosal corona

FIG 95 —Ulcer crater in the right fornix of the bulb in which barium has silted Associated spasm of the left border

(a) (b)

FIG 96 —(a) The prestenotic diverticulum of Akerlund (b) Ulcer crater on the base of the duodenal bulb

tion though commoner in persons of hypersthenic build is by no means confined to them, and hypotonia and slow evacuation are not uncommonly present

Indeed, the observations of Hurst regarding the pyloric function in gastric

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tion though commoner in persons of hypersthenic build is by no means confined to them and hypotonia and slow evacuation are not uncommonly present

Indeed the observations of *Hurst* regarding the pyloric function in gastric

ulcer and its effect on the function of the stomach apply with equal force here In duodenal ulcer there may be found one of the three abnormalities of the pylorus—achalasia pylorospasm, or organic stenosis, or a normal pyloric *function may obtain*

These gastric changes constitute, therefore, interesting but unimportant confirmatory parts of the radiological picture of duodenal ulceration, and of themselves afford no specific diagnostic indication of ulcer in that site

In a certain percentage of cases localised tenderness on pressure over the duodenal lesion is present It is said to be the result of peritoneal involvement and periduodenal adhesions It is a variable sign Frequently the tender point is in the epigastrium well above the duodenal bulb It is of no value as an independent sign

The last word in the discussion of the X ray diagnosis of duodenal ulcer should be to emphasise the cardinal importance of the niche, the ulcer crater itself Too often it is not possible to demonstrate it, and reliance must be placed on the general bulb deformity—the coral, the pine tree, the clover, etc While these are most commonly due to duodenal ulceration they may result, in occasional cases, from such diverse lesions as healed ulcer duodenitis cholecystitis, appendicitis periduodenitis, or even mere incomplete filling

The niche itself properly demonstrated end on and in profile is the only pathognomonic sign of active ulceration, and the other deformities of the bulb are more properly indices of associated œdematous, spastic, or cicatricial changes

Healing of a Duodenal Ulcer —This is a problem which frequently presents itself in radiological practice, and is often a difficult one Whilst it may be fairly simple to establish the presence of a duodenal ulcer initially, it is often a matter of great difficulty to decide how much residual deformity will ultimately occur on healing

In considering this the factors producing the deformity must be borne in mind, and it is of first importance that the initial radiograms of the ulcer and the succeeding check examinations be of the highest quality Only then can the gradual disappearance of the deformity be analysed

To determine the presence of a healing process the ulcer crater should be looked for first It must disappear Its radiographic disappearance is not conclusive, as the crater may be visible only because of the surrounding mucosal œdema The œdema is usually the first of the factors to disappear In the case where the crater is invisible on the disappearance of the œdema the persistence of a spastic incisura of the bulb may indicate that the lesion has not entirely healed The spasm is, as a rule, the last temporary factor to disappear, leaving a varying cicatricial residue This last may range from a virtually normal bulb outline to quite marked stenotic deformity In the latter case, the fact of healing cannot be established by radiographic means alone In the presence of marked cicatrisation prolonged absence of *all symptoms* would be necessary to warrant such a conclusion

It follows from the above considerations that a healed duodenal ulcer can with certainty be shown radiographically to be so only if no cicatricial deformity remains after healing The more the residual scarring, the less certainty is there in the radiographic demonstration of healing, and the more reliance must there be placed on the clinical evidence on this point

In an extreme case, where a secondary diverticulum has followed ulceration, it may be quite impossible to distinguish this from a deep ulcer crater but the deepest of craters usually shows some lessening of size under vigorous medical treatment, and if no diminution in size is observable in a series of examinations spread over a course of treatment, the presence of a secondary diverticulum or pouching is to be suspected rather than that of a deep ulcer

Gastric Stasis following Duodenal Ulcer.—This is a not uncommon sequela of chronic duodenal ulceration, and is caused chiefly by cicatricial *contraction, with a superadded element of œdema, if active ulceration persists, as it usually does*

In the less severe degrees it may be easy to demonstrate the stenosed irregular passage, but in the severe degree this may take considerable pains and patience The secondary gastric signs, as described under pyloric stenosis will be present to an extent depending on the severity of the narrowing

It may not be possible to determine whether the obstruction is in the bulb alone or in the pylorus as well, but the point is of little importance, so long as there is no sign of involvement proximal to the pyloric ring This would raise *the possibility of carcinoma a condition which may virtually be left out of consideration on the distal side of the sphincter*

DUODENITIS

This has become a popular diagnosis of recent years and although doubt has frequently been cast on its existence, it has now been proved pathologically to be a clinical entity A certain degree of duodenitis nearly always accompanies a duodenal ulcer, but *Kirklin* has published a series of thirty two cases in which the presence of duodenitis and the absence of an active or healed *ulcer have been proved histologically*

The bulb is the most common site but the inflammatory process may extend down as far as the ampulla of Vater (i e the point of acid neutralisation) *McCarty* gives an account of the pathological features as those of cellular destruction with œdema, vascular congestion, and leucocytic infiltration Macroscopically, the mucosa is œdematous and reddened, with occasional minute erosions

THE X-RAY FEATURES are dependent on spasm of the muscularis and œdema of the mucosa The changes may be seen in the bulbar and post-bulbar portions, and in the filled and empty lumen In a marked case they are fairly typical

In the bulb, the first point to be noticed is its filling Owing to general

increased tonus in the bulb the contrast medium when projected through the pylorus fails to distend the cap to its normal proportions and whatever incomplete filling does occur is speedily dispersed A radiogram taken at the moment of filling shows a small cap with a hazy or spiky contour If taken a second or so later the mucosal pattern of the bulb becomes visible (if not of itself then with graduated compression) It takes the form of a coarse reticulum the result of broadening and coarsening of the mucosal folds Together with this broadening is a loss of flexibility so that it is difficult to obliterate them by pressure Between the folds there may occur irregular deposits of barium simulating an ulcer crater but no true ulcer crater is seen This though a negative statement requires emphasis since the presence of such a crater must be meticulously excluded before pronouncing the condition to be the simpler one Distinguishing features are the absence of a niche projection in profile and the inconstancy of the pseudo niche at subsequent examination

The duodenum between the bulb and the ampulla if involved in the inflammation, shows radiographic changes depending on the degree of mucosal œdema and muscular hypertonus

During the phase of filling the barium filled lumen is seen to be narrower and its margins scalloped to some extent The latter is due to the indentation of the barium shadow by the œdematous mucosal plicæ When peristalsis has emptied the lumen a coarse mucosal pattern is visible similar to that seen in the bulb

According to *Kirklin* duodenal obstruction rarely results from simple duodenitis nor is gastric stasis a feature thereof

PERIDUODENITIS

This too is a popular diagnosis of recent years and there is a tendency so to label any vague irregularity in the duodenal contours in which no very definite pathological lesion is demonstrable It is a comfortably vague and non committal diagnosis one which does not tempt to surgical interference and one to be avoided unless on the clearest possible evidence

Duval describes two types periduodenitis involving the bulb and periduodenitis involving the third and fourth portions

Bulbar Periduodenitis may involve the whole bulb or merely the apex In the former the bulb is small adherent irregular in contour and inextensible Its differentiation from true duodenitis would thus depend on the demonstration of a normal mucosal pattern in the bulb a thing rather difficult to do because of the serous thickening In the type limited to the apex of the bulb the main body of the bulb is normal in contour and only its apex shows irregular constant contracture Various causes are ascribed to this condition In some no cause is demonstrable others result from cholecystitis duodenal ulcer, or adhesions It is obvious that in those cases in which the primary cause in the gall bladder or duodenal mucosa is visible the periduodenitis is an inci

dental state quite overshadowed by the major lesions, and the closest search must be made for such primary condition in all cases in which a suspicion of bulbar periduodenitis is raised by the radiological examination The demonstration of duodenal ulcer and gall bladder disease is as a rule easy, and any considerable adhesions may cause a displacement of the bulb either in front of or behind the stomach The anteposed bulb may result from its adhesion to a large dilated gall bladder to the anterior edge of the liver, or to the anterior abdominal wall The retroposed bulb is usually adherent to a small retracted gall bladder, or to Spiegel s lobe of the liver

PERIDUODENITIS OF THE THIRD AND FOURTH PORTIONS results in a mild stenosis and a mild duodenal ileus Its appearances are discussed in that section

PERIDUODENITIS AFTER CHOLECYSTECTOMY —The duodenal bulb very commonly shows a deformity following this operation, the result of adhesions These if marked may cause duodenal stenosis and consequent post-operative abdominal symptoms They may, however, exist in the presence of complete clinical cure

DUODENAL FISTULÆ

These may be external or internal

EXTERNAL FISTULÆ are rarely seen in X ray departments They may result from operations on the duodenum, bile tract, or right kidney, or be due to pathological conditions of the duodenum (notably ulcer) or to injury The condition is usually evident clinically from the nature of the discharge and its digestive effect on the skin, but in those cases where there is slight discharge only and little cutaneous reaction the nature of the fistula can easily be determined by injection of an opaque medium, e g barium cream sodium iodide or lipiodol and its radiographic demonstration in the duodenal lumen

OF THE INTERNAL FISTULÆ the *cholecysto-duodenal type* is by far the commonest These result usually from ulceration of a gall stone through into the duodenum or from perforation of the gall bladder by a duodenal ulcer Fistulæ due to carcinoma have been recorded The radiographic demonstration of these fistulæ depends on observing the passage of a *barium meal into the gall bladder If the bile ducts also fill, the nature of the* condition is evident, but if not, a lateral radiogram is necessary to differentiate the barium filled gall bladder from a duodenal diverticulum

The next commonest type according to *Naunyn* and *Roth* are the *choledocho-duodenal fistulæ* arising from ulceration of a gall-stone impacted in the common bile duct With good fortune barium may pass into the bile ducts and render the fistula evident radiographically, but this does not always occur Rarer fistulæ are those between the *duodenum* and the *stomach* *colon* and *right renal pelvis* respectively The *duodeno-gastric type* is best demonstrated by a barium meal, the others by a barium enema and instrumental pyelogram respectively

CHAPTER XII

MISCELLANEOUS DUODENAL LESIONS

DUODENAL DIVERTICULOSIS

THE DIAGNOSIS of this is exclusively radiological as the majority of cases are symptomless and in the rest the symptoms are in no way characteristic *Case* in 1913 was the first to diagnose a case by a barium meal

FREQUENCY —*Linsmayer*, in 1,367 autopsies, found duodenal diverticula in 3 3 per cent of cases

The percentage found in barium meal examinations varies, according to different investigators between 18 per cent and 5 19 per cent *Case* (1920) in 6 847 barium meal examinations, found diverticula in 1 2 per cent and *Spriggs* 3 8 per cent in 1 000 cases

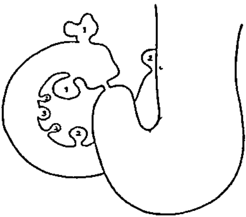


FIG 97 —Types of duodenal diverticula 1 Secondary 2 Primary 3 Ampullary

CLASSIFICATION — *Odger s* grouping appears to be the most satisfactory He divides duodenal diverticula as follows *primary secondary* and *ampullary* (Fig 97)

Primary Diverticula

The diverticula of this group show the following characteristics

(1) They occur only in the second third, and fourth parts of the duodenum The second portion is much the commonest site, about 75 per cent of all primary duodenal diverticula being in this segment A large majority are situated within an inch of the ampulla of Vater—the "diverticules perivateriens of *Letulle* A second fairly common site is at the duodeno jejunal flexure Here they project upwards

(2) They are sometimes multiple, two being present, and, rarely three When two are present, they are commonly situated one on either side of the ampulla

(3) They are more commonly on the concave surface of the duodenum and grow into, behind, or against the head of the pancreas Sometimes they lie behind the duodenum, and if large they may sag downwards and lie below the duodenum

(4) They are flask shaped mucosal protrusions of the mucosa through the muscular coat, sometimes carrying with them an expansion of the muscularis

(5) They are best developed in elderly patients

(6) In size they vary from a pea to a walnut

(7) They are probably of congenital origin

Kellogg divides the above class into true and false diverticula according to the composition of the wall thereof. The true diverticula have a wall including all coats of the duodenum. These he regards as congenital. False diverticula, he states, are acquired and are composed mainly of mucosa.

FIG 98 —Small duodenal diverticulum near the ampulla

PATHOLOGY —The great majority of these diverticula are discovered accidentally and cause no pathological changes. In a small number of cases changes do occur and are associated with symptoms. *Odger* gives a full account of the sequelæ which may occur, the best established of which are

(1) *Diverticulitis* —This may go on to ulceration and perforation

(2) *Peridiverticulitis* with adhesions to the pancreas

(3) *Mechanical compression* by a distended diverticulum on the duodenum and common bile duct, causing duodenal ileus and biliary obstruction respectively

Duodenitis, cholangitis, acute and chronic pancreatitis are rarer complications which have been described. In one case a cholesterin stone was found in a diverticulum

THE SYMPTOMATOLOGY in those cases which give rise to symptoms falls into one of several groups

(1) *Vague digestive disturbance* with distension, flatulence, and nausea

(2) *Peptic ulcer symptom complex*

(3) *Biliary symptoms,* with jaundice and colic. These occur particularly in perivaterian pouches

(4) *Symptoms of acute pancreatitis*

X RAY FEATURES —The characteristic feature is the presence of one or more rounded barium shadows near the concave border of the duodenum (Figs 98 100). Under screen examination the pouch can be made to fill from

and empty into the duodenum and tenderness over the shadow indicative of diverticulitis may be determined. Fixation of the diverticulum may be noted on palpation. This is of no great significance since while it may be due to peridiverticulitis it may be due merely to the pouch being deeply embedded in the pancreas. The presence of stasis in the pouch is of importance (Fig 101). The writer has seen two cases in which a peptic ulcer symptom-complex was present and in which six hour stasis occurred. In one

Fig 99. Large diverticulum (1) of the second portion of the duodenum. Stasis occurred in it up to [illegible] hours. The greater curve of the stomach shows an associated gastritis.

of these cases removal of the diverticulum was followed by disappearance of the symptoms.

The mucosal relief pattern may in some cases be traced from the duodenum through into the pouch.

Usually the erect posture is sufficient to show these diverticula and in this position a horizontal fluid level may be visible if the pouch be large enough to contain gas. Sometimes the horizontal posture is necessary to fill them. This applies particularly to those projecting upwards from the duodeno-jejunal flexure. Pressure on the duodeno-jejunal flexure may, by distending the duodenum, help to fill them.

Differential Diagnosis.—In most cases the nature of the condition is quite evident but at times it may be mistaken for other conditions. The

commonest error is to mistake a diverticulum of the fourth part of the duodenum for a niche on the lesser curve of the stomach. This simulation occurs only when the lesser curve of the barium filled stomach half overlaps the diverticulum, and its true nature is apparent as peristalsis proceeds. Diverticula are distinguished from other shadows which may be present in the neighbourhood of the duodenum—e g calcified gall stones or glands—by the permanence and lesser density of the latter.

Primary diverticula near the ampulla may be indistinguishable from the ampullary type, and if near the first part of the duodenum it may be difficult to distinguish them from secondary diverticula. Deformity of the bulb usually present in the latter affords the clue.

Fig 100. *Diverticulum of the second portion of the duodenum.*

Secondary Diverticula

These are found only in the first portion of the duodenum, have a *complete muscular coat*, and are secondary to an adjacent lesion, most commonly a duodenal ulcer. They may be either pulsion or traction, *and are rare compared with the primary variety.*

Of the *pulsion* type the most common is that found opposite ulcer scars. *The scarring causes contractures*, and the shallow pouch so formed gradually becomes deeper by continued pressure. The neck of the pouch is usually wide.

Wilkie has described three cases of "ulcer diverticulum," in which a dense fibrous sac was formed, the bowel wall having been destroyed *by ulceration.*

The *traction* group of secondary diverticula result usually from the drag of adhesions between the duodenum and gall bladder, lesser curve, or appendix.

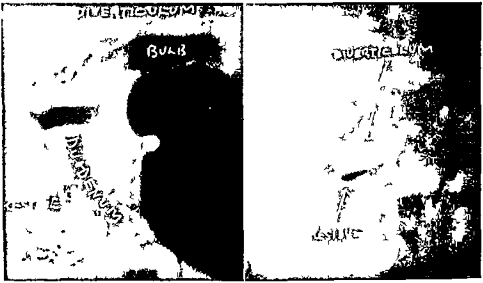
X RAY FEATURES.—These diverticula tend to be larger than the primary type, and are *often irregular in shape and wide necked.* They are associated with some deformity of the duodenum from either scarring or ulceration. Sometimes these diverticula are large and would be more accurately described as pouchings of the duodenal wall, with no appreciable neck. These larger *more open pouches merge with the group of cases described under the term* "looped duodenum."

The Symptomatology of secondary diverticula is that of the primary lesion but occasionally they are associated with dyspeptic symptoms even when the primary causative ulceration has disappeared

Ampullary Diverticula

Two types of these occur

(1) When the papilla of the bile and pancreatic ducts opens into the fundus of a small duodenal pouch This has no clinical significance Its only radio



(b) (a)

Fig 101 Diverticulum of the second portion of the duodenum (a) 6 hours after a barium meal (b) On refilling the stomach

logical significance is that it cannot be distinguished from a peri vaterian diverticulum

(2) Dilatation of the ampulla of Vater itself The cause be it congenital or acquired is uncertain *Possibly some develop* as a result of impaction of a gall stone It is of importance clinically according to *Case* who states that it is associated in 70 per cent of cases with chronic pancreatitis

Radiologically these appear as small round or oval barium filled pouches a few millimetres in diameter in the second portion of the duodenum at the site of the ampulla

The ampulla of Vater may however fill with an opaque medium apart from either of the above two abnormalities This is a not infrequent occur rence and without significance except in the matter of differential diagnosis

It is seen radiologically as a small fleck medial to the mid point of the second ·rtion *of the duodenum , mobile, painless on pressure, and showing no fluid* ·vels such as are seen in true diverticula

CHRONIC DUODENAL ILEUS

Wilkie was the first to draw attention in this country to this condition ·a clinical entity Simultaneously it had been recognised by American and ·rench observers *As described by Wilkie, its essential feature is a partial* ·*struction of the third part of the duodenum by pressure on it of the superior* ·esenteric vessels and the mesenteric root in which they are contained *·raas* and *Beck* have drawn up a wider classification, on which the following ·based

(1) **Non-obstructive Ileus** Megaduodenum

(2) **Obstructive Ileus**

INTRINSIC From neoplasm duodenitis, congenital atresia, diverticula

EXTRINSIC Chronic arterio mesenteric obstruction, adhesions, jejunal ·enosis after gastro jejunostomy, pressure from extrinsic tumours of glands ·ancreatic abnormalities such as tumour abscess or annular pancreatic head ·*rrounding the duodenum*

·egaduodenum

This type is easily recognised radiographically, as it is not dependent on ·rganic obstruction Two theories are held regarding its ætiology that it is a ·ongenital abnormality, and alternatively that it is the result of a neuromus ·ular incoördination and allied to Hirschsprung s disease Proof of either theory ·, so far, wanting Patients exhibiting this condition are of hyposthenic type, ·nd the duodenal cap is involved in the dilatation In the erect position barium ·*ends to collect in a pool in the dependent portion of the duodenum and* ·*uodenal bulb Examination in the supine or prone position serves to outline* ·he duodenum more fully, and also *shows free passage of the contrast medium* ·nto the jejunum The mucosal pattern of the duodenum is unaltered in ·his condition

·bstructive Ileus from Intrinsic Lesions

These lesions are rare some of them extremely so In addition to the ·bstructive dilatation of the duodenum, there may be present in the case of ·ome of them the radiographic evidence of the causative lesion

·bstructive Ileus due to Extrinsic Pressure

Chief amongst these are arterio mesenteric occlusion and jejunal obstruc- ·ion after gastro jejunostomy

In the first of these, *chronic arterio mesenteric occlusion*, the essential factor

in the ætiology is pressure of the superior mesenteric vessels and the mesenteric root

Any factor which lessens the angle between the superior mesenteric artery and the aorta will tend towards duodenal occlusion A congenital abnormality might do so and this is doubtless the explanation of those cases occurring in childhood with gastromegaly and megaduodenum up to the point of crossing of the vessels

As the condition usually develops in adult life another factor must take effect some traction on the mesentery and one which will account for the intermittent nature of the symptoms Enteroptosis provides this effect in

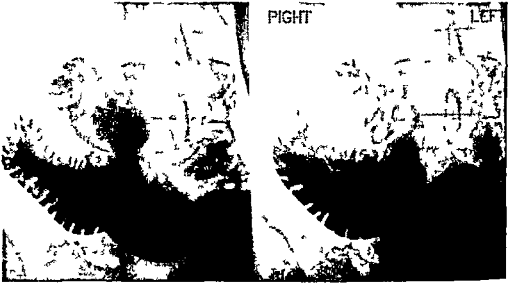


Fig 10 —Two phases in a serial radiogram of a case of arterio mesenteric duodenal ileus (proved at operation)

two ways—by the drag of the small intestine on the mesentery and by similar traction of the right colon on the mesentery when the colon is unduly mobile and dependent and the cæcum ptosed into the pelvis In rare cases an abnormal right colic artery is the offending vessel descending almost vertically across the duodenum as described by *Gregoire*

The symptomatology is suggestive a history of bilious attacks in a visceroptotic type of female patient gradually getting worse after the age of 30 epigastric discomfort and flatulence following all meals and relieved by lying down or especially the genupectoral position The bilious attacks typically consist of a day of headache nausea and epigastric discomfort followed by vomiting at first clear and later bilious Following this the symptoms are relieved Constipation usually ushers in the attacks which tend to recur every month or so

Radiographic Features—All degrees between an apparently normal duodenum and gross dilatation may be found The gross degrees are rare but minor degrees are not uncommon and may require no treatment *In mild cases there may be no abnormality to be seen in the duodenum between the attacks* In an established case a typical picture is presented (Figs 102 103) The duodenum is dilated may be grossly so The valvulæ conniventes persist but are thin and widely spaced in gross cases This is due to the stretching of the mucosa between the valvulæ and is not seen in congenital megaduodenum

FIG 103—Arterio mesenteric duodenal ileus supine view

Screen examination presents a typical appearance The duodenal peristalsis is active and often writhing and reverse peristalsis commonly present gives a to and fro or pendulum movement to the duodenal contents which is quite characteristic of obstruction Often the appearance is curiously like that of a reversing cog wheel

On tracing the duodenum up to the point of obstruction it will be seen that *there is no sign of annular constriction* but that *the bowel is flattened against the spine* its lumen being reduced to a vertical slit A further characteristic feature is the appearance of the mucosal pattern Frequently in

these cases the normal cross hatching of the plicæ changes at the point of obstruction to longitudinally disposed rugæ Owing to the intermittent nature of the dilatation in many of the cases it is of importance to examine the patient radiographically at the beginning of the attack If seen at that stage the radiographic picture is definite and characteristic

Obstruction from Periduodenitis—This produces a mild degree of ileus since the obstruction is not gross It presents certain radiological features which may help to distinguish it from the arterio mesenteric variety The obstruction is more constant Two manœuvres are available to test the con stancy or inconstancy of an ileus *Hayes* method consists in attempting to raise the mesentery by manual palpation with the patient in the erect position and so relieving the obstructive pressure on the duodenum It is a difficult and uncertain procedure and its aim is much more surely accomplished by placing the patient in the knee elbow position If it is too difficult to screen the patient in this position a compromise may be adopted—that of the ventral position—with cushions so arranged under the pelvis as to prevent direct pressure on the abdomen

These procedures if successful relieve the obstruction in arterio mesenteric ileus but not in that due to periduodenitis Posture of this type is al o a use ful therapeutic measure in arterio mesenteric ileus and the relief from symptoms so obtained forms a therapeutic differential test

Obstruction from Adhesions and Bands congenital and acquired form a not uncommon group The radiographic appearance may be very varied depending on the disposition of the bands but they are less likely to be relieved by posture than the true arterio mesenteric variety

Obstruction from Pressure of Extrinsic Tumours —Carcinoma of the head of the pancreas may obstruct the distal portion of the duodenum so as to produce ileus but more commonly the whole duodenal loop is stretched and *flattened round the enlarged pancreatic head In a radiogram after* a barium meal the stomach shows dilatation and stasis and the duodenum takes the form of a thin streak in rather a wide circle A cyst or abscess of the pancreatic head produces a similar appearance

Kellogg has collected from the literature twenty five cases of duodenal obstruction from annular pancreas the head of the pancreas being in the form *of a ring surrounding the duodenum In the majority of these the proximal* duodenum was dilated

Ileus following Gastro jejunostomy —This in the writer s experience is the commonest type of chronic duodenal ileus It may occur in several of the stenotic sequelæ of that operation but it is most marked when the stoma and adjacent jejunum are stenosed and the pylorus patent If marked the ileus may be gross *In contradistinction to the arterio mesenteric type of ileus* the dilatation involves the whole of the duodenum and the proximal limb of the jejunal anastomotic loop

Duodenal Ileus in Children

The condition is rare in children and falls into two classes

(1) The acute type from gross obstruction—either arterio mesenteric or atresic These are not usually seen in an X ray department *Schinz* and *R W Bolling* have each reported a case of congenital atresia in which the proximal duodenum reached a large size and formed a bulbous sac as large as the stomach In the latter s case this was seen radiographically eight days after birth

(2) The chronic type getting worse as ptosis develops Gastromegaly develops more markedly *than in adults* and may *in the radiographic examination mask the duodenal ileus Miller* and *Courtney Gage* have reported a series of this type

Duval reports a case of cyclical vomiting of infancy in which a typical arterio mesenteric ileus was found with violent to and fro peristalsis The attacks were at once relieved by the ventral posture

MEGABULBUS

The duodenal bulb may be large from several causes

The congenital type is rare It is recognised by the considerable disparity between its size and that of the antrum and by the entire absence of obstructive abnormality distal to it (Fig 104)

Fig 104 —Megabulbus or [illegible]to-major bulb
The actual size was [illegible] inches across

A milder degree of dilatation is often present in hyposthenic individuals and is reasonably accountable as being due to diminished tone

A third type is that due to some obstruction in the duodenum distal to it *such as scarring from ulcer at the apex* of the bulb *or stenosis of the duodenum at the* junction of the first and second portions by cholecystic adhesions or periduodenitis The radiological differentiation of these types depends on the recognition of the obstructive lesion or the hypotonia or their absence in the case of the congenital variety

MICROBULBUS

The duodenal bulb may be anatomically small in which case it is regular in contour or from cicatricial contracture when it is irregular or finally from general spasticity when it is uniformly spiky

DUODENUM INVERSUM

This term has been used to describe a reversed disposition of the duodenal loop the food travelling through the duodenum in a clockwise circle instead of the normal Two varieties are described a mobile and a fixed

Mobile Inversion —This abnormality is dependent on the presence of a meso duodenum which allows the first and second portions to sag down and

Fig 105 Mobile type of duodenum inversum or looped duodenum

so reverse the direction of the duodenal loop It is said to be associated with a hypotonia

Allied to this is the condition described as *looped duodenum* in which the first portion of the duodenum is dilated and possesses a mesentery (Fig 105) This mesentery is short or non-existent at the pylorus and bulb As a result when a barium cream passes through the pylorus with the patient erect it spills *down into the dependent loop and then because of the dilatation tends to* form a pool This empties into the second portion by overflow The drag of this loop often causes a flattening and distortion of the bulb

In the supine and prone positions the looping is less evident, or the loop may be entirely restored to the normal position

In the fixed form the inversion is complete, and only the first portion of the duodenum is mobile *Sandera* describes the radiographic features of seven cases

MORPHOLOGICALLY the inversion is complete, and the bulb is kinked downwards Variation in posture reveals that only the first part is mobile The position of the remainder is constant The pylorus and duodeno jejunal flexure are situated normally, to the left of the midline The stomach is of the ptosed hypotonic type

The following functional changes are seen a tendency to to and fro or pendulum movement of the contents of the loop, and stasis therein In a case illustrated by this observer the loop showed a mild ileus

CLINICALLY symptoms may be present, but whether caused by the abnormality or by an associated state, such as Glenard s disease, is uncertain Epigastric discomfort after food a feeling of distension, nausea, and sometimes actual pain have been noted, but they do not constitute a characteristic symptom complex

SITUS INVERSUS PARTIALIS, COMMUNE MESENTERIUM

In this congenital abnormality, described in detail in the section on the colon, the third part of the duodenum does not cross the midline, and there is no duodeno jejunal flexure underneath the superior mesenteric artery The third and fourth parts of the duodenum descend to the right flank to join the jejunum, which with the ileum occupies that part of the abdomen

BENIGN TUMOURS OF THE DUODENUM

These are rare, but not so much so as carcinoma The commonest varieties met with are myoma adenoma, fibroma and lipoma As they increase in size they may cause duodenal obstruction and give the radiographic picture of that complication They tend to become pedunculated, and then produce a mobile filling defect in the duodenum

When large and pedunculated they may cause duodenal *intussusception* Of a series of ten cases of intussusception collected by *Kellogg*, three were diagnosed radiographically as simple stenosis, malignant stenosis, and adhesions respectively The last case is reported by him in detail—a fibroma attached to the duodenal wall near the pylorus and the tumour, pylorus and duodenum invaginated into the jejunum The radiogram showed the pylorus invaginated into the duodenum, and a filling defect from the tumour invaginated into the jejunum.

CARCINOMA OF THE DUODENUM

This is a rare disease being reported to represent 2 per cent of all primary malignant growths of the intestine It is commonest in the second portion According to *Rolleston* 60 per cent of cases occur in that site

Pathologically there are two types cylindrical celled tending to produce *an annular construction and spheroidal-celled The latter type forms a flat* plaque or a deep fungating ulcer

The Radiological Features vary according to the pathological type and the site

(1) SUPRA AMPULLARY —The symptoms are those of pyloric carcinoma and radiographically the condition is mistaken for a duodenal ulcer if the pyloric canal is intact If the pyloric ring is involved in the growth pyloric carcinoma or pyloro duodenal ulcer are the conditions for which it is liable to be mistaken

(2) AMPULLARY —Intermittent jaundice is an early feature A barium meal will show a filling defect and/or a duodenal ileus from obstruction by the lesion

(3) INFRA AMPULLARY —In these cases there is a considerable tendency to obstructive ileus Clinically vomiting is a feature the vomit containing bile and pancreatic ferments

Radiographically a duodenal ileus is evident and possibly a filling defect from the obstructing growth

THE DUODENUM IN ENLARGEMENTS OF THE HEAD OF THE PANCREAS

The duodenum shows a typical appearance in these enlargements what ever the cause be it carcinoma sarcoma cyst or abscess This consists in a widening of the duodenal circle and a flattening and compression of its lumen As the duodenum is wrapped round three quarters of the head of the pancreas *obviously any enlargement of the latter will tend to spread out the duodenal arc* and to stretch and flatten it as a tube Gastric stasis is a common sequela With considerable enlargements the pyloric antrum may be raised and the duodeno jejunal flexure depressed The commonest type of enlargement is carcinoma in which condition the diagnosis is usually settled by obstructive jaundice

CHAPTER XIII

THE STOMACH AND DUODENUM AFTER OPERATION

X-RAY EXAMINATION *of the stomach or duodenum which has been the seat of* surgical interference frequently presents a problem of great difficulty

In the case of the intact stomach the examination is made easy by the possibility of filling it out to its normal contour As a rule however with the stomach after operation this is not possible and a wide variety of appearances may present themselves in the absence of any pathological condition It is the difficulty of disentangling these normal variations from the pathological which constitutes the problem

TECHNIQUE

Because of the above consideration the radiographic technique must be *modified in some respects Screen examination is even more important than in the intact stomach and the demonstration of the mucosal relief pattern is* of greater value

The technique must be varied according to the precise operation performed and it is most desirable to have this information before commencing the examination

From a radiographic point of view these cases fall into broad classes those in which sphincteric control of gastric evacuation has been abolished and those in which it has been retained Some operations fall between these two groups as follows

(1) Sphincteric Control Retained

Simple excision or cauterisation of a gastric ulcer

Wedge resection

Sleeve resection

Gastro gastrostomy

Duodeno jejunostomy

(2) Sphincteric Control Partly Retained

Pyloroplasty

Schoemaker s operation

Billroth I

Although in all these the muscular pyloric sphincter is either cut or *removed yet enough control of efflux is exhibited by the stomach to warrant the above term in classification*

(3) Sphincteric Control Abolished

Gastro jejunostomy (Only when abnormal contracture of the stoma has taken place, is there any degree of control)

Billroth II

Polya and its modifications

Finney's pyloroplasty

In the First Group, with retention of sphincteric control, the technique should follow that described for the intact stomach Special attention should, however, be paid to the relief pattern, both under the screen and in serial radiograms The erect, supine, and prone positions are all of value, and the *most suitable for taking radiograms will be determined by the fluoro* scopic appearances

In the Second Group, again, where partial control has been established the normal technique may suffice, but means should be at hand to control the gastric efflux, should this prove to be too rapid to allow satisfactory and complete filling of the stomach Such means are indicated in the succeeding paragraphs

It is in the Third Group, with abolition of sphincteric control, that most difficulty occurs A wide communication exists between the lower part of the stomach and the small intestine, and the gastric contents are rapidly poured out into the jejunum It is impossible to distend the stomach, or stump of the stomach in gastrectomy, unless the efferent jejunal loop be occluded by pressure This can be done by hand temporarily under the screen but this immobilises the palpating hand, and cannot be kept up indefinitely Some form of mechanical compressor or truss is much to be preferred A well known type is the *Chaoul* compressor In this, a metal ring, 5 inches in diameter, supports a rubber bag which can be inflated to a hemisphere It is strapped to the patient s abdomen by an attached broad webbing band and buckle Pressure on the required area is induced and maintained by the inward bulge of the bag *The objections to it are the difficulty of precise adjustment and the* shadow of the metal ring

Berg's pressure cone and serial radiographic apparatus, although designed primarily to study the relief mucosal pattern of stomach and duodenum will serve to control the stoma of a gastro jejunostomy Its disadvantage for the latter is the small aperture it possesses, limiting the fluoroscopic and radiographic field

The writer has designed an adjustable truss which answers the latter purpose—control of the efferent loop—satisfactorily It consists of two portions—a leather covered spring band similar to that of an ordinary hernia truss and an adjustable compression pad Three or more spring bands are necessary, to fit varying sizes of patients The adjustable pad comprises a base slotted for the reception of one end of the appropriate spring band, an arm hinged on this base giving, by means of a small thumbscrew and worm gear, an anterior and

posterior angulation and a leather padded aluminium pad The arm is *slotted throughout its length and the pad can be adjusted along its length by* a butterfly nut The hinged arm has an upward bend so that the compres sion pad is above the level of the spring band when fitted to the patient This avoids obscuration of the field under examination by the shadow of the spring Reference to the diagram will indicate the details of the truss (Fig 106)

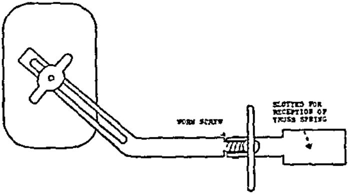


FIG 106 —Truss compressor

The technique for each individual case will vary according to cir cumstances but that which the writer uses as a basis is as follows

The examination is commenced in the erect position, and under fluoroscopic control the patient drinks one mouthful of the opaque cream This gives a pre *liminary screen survey of the relief pattern of the stomach the stoma* and the efferent loop after which a radiogram is taken The truss is then fitted with the spring band just *below* the iliac crests and the pad over the efferent loop The patient then drinks a few more mouthfuls and the pressure of the pad is increased by turning the worm nut till obstruction of the loop is obtained Sufficient of the meal is then drunk to distend the stomach

Antero posterior serial and left lateral radiograms are then taken and the compressor removed Removal of the latter is a matter of a few seconds The rate of emptying of the stomach is then noted fluoroscopically, attention being paid to any tender points over the stomach duodenum and stoma The degree of jejunal overloading if any should be noted

In a few minutes the stomach will as a rule have largely emptied itself and enough of the cream will remain therein to permit a further observance of the *mucosal relief pattern in the prone and supine positions Radiograms may* be taken in these positions if necessary

The patient should again be screened half or one hour later to determine the amount of residue in the stomach

Such is the average technique required in these Group III cases but the study of each case should be individual and no cast iron routine should be adopted in the technique

Before considering the normal and pathological appearances after operation it is desirable briefly to outline the nature of each Some of the operations described below are but rarely performed and still less frequently seen in an X ray department Others such as posterior gastro jejunostomy and partial

gastrectomy are *très à la mode* and such patients are frequently referred for X ray investigation

OPERATIONS RETAINING SPHINCTERIC CONTROL

Simple Excision or Cauterisation of a lesser curve ulcer The operation requires no description It is rarely performed now The radiographic appearances are shortening of the lesser curve puckering at the site of operation and local disturbance of the longitudinal rugæ in the relief pattern (The operation is usually combined with posterior gastro jejunostomy—Balfour s operation)

Wedge Resection of the Lesser Curve —This is also out of fashion because of the tendency to recurrence The radiographic appearances above are accentuated Hour glass stomach is said to occur frequently after this operation The resection on the lesser curve causes scarring and contracture on that side of the stomach and the greater curve may show a spastic incisura for a time accentuating the biloculation

Sleeve Resection —This operation consists of segmental resection of the lesion bearing area usually in the middle portion of the stomach with end to end anastomosis It is rarely performed now

A certain amount of deformity may occur at the suture line owing to disparity in the sizes of the anastomosed ends Some contracture of the anastomosis usually takes place and shows radiographically as a notching of both curvatures at the site of anastomosis This commonly gives an hour glass appearance

This contracture does not necessarily mean that the operation has been unsuccessful It is compatible with a satisfactory physiological result and should not be regarded as of serious importance unless an ulcer crater is also visible in the region of the lesser curve

The mucosal relief pattern is disturbed at the suture line According to *Kerley* a temporary pyloric insufficiency with duodenal dumping results from the section of the nerves

Gastro gastrostomy an anastomosis performed of yore between the two sacs of an organic hour glass stomach It has been entirely superseded The radiographic appearances would be those of a double channel in the stomach with considerable irregularity *Duval* reports several such cases

Duodeno jejunostomy —This is the operation of choice in chronic duodenal ileus involving the whole duodenum The duodenum is mobilised brought through the transverse mesocolon and anastomosed laterally to the jejunum a short distance below the duodeno jejunal flexure (Fig 107)

On comparison with radiograms taken before the operation the duodenal dilatation will be seen to have diminished or disappeared and the opaque medium to pass through the stoma into the jejunum (Fig 108) The stoma may be hidden in the erect position by the stomach if the latter be ptosed and dilated If so the supine position will bring it into view

Cholecysto-gastrostomy — This operation is performed for complete obstruction or destruction of the common bile duct, and consists in anastomosing the fundus of the gall bladder *to the anterior surface of the pyloric antrum* The radio graphic appearance with a barium meal is quite typical The gall bladder fills with barium, and in the erect position the upper part of the gall bladder contains an air pocket above the barium The cystic and hepatic ducts may also fill, and are prone to do so, since they are usually to some extent dilated as a result of the obstructive lesion for which the operation was performed

Cholecysto - duodenostomy — In this a similar radiographic appearance is seen, save that the anasto mosis is between the fundus of the gall bladder and the mobilised second portion of the duodenum The connections of the viscera are then the same as obtains in calculous cholecysto duodenal fistula

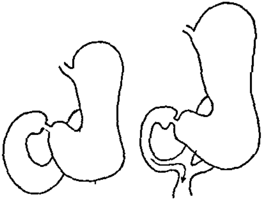


Fig 107 — Duodeno jejunostomy

Fig 108 — Normal appearance after *duodeno jejunostomy for arterio mesenteric* duodenal ileus

OPERATIONS RETAINING PARTIAL SPHINCTERIC CONTROL

Simple Pyloroplasty — This con *sists of a longitudinal incision of the pyloric canal, in cases of simple pyloric stenosis* the incision being *sutured transversely* (Fig 109) It is rarely if ever performed now gastro enterostomy or Finney's operation being used in its stead The radio graphic contours of the pylorus and duodenal bulb are grossly distorted by this

Fig 109 — Simple pyloroplasty

operation and unless previous information as to the operation were available it would be mistaken for pyloro duodenal ulceration or scarring

Billroth I (known in France as *Pean s* operation) —This is in essence a partial gastrectomy with end to end anastomosis of the cut duodenum to the lower portion of the gastric stump (Fig 110) The upper portion of the gastric cut end is closed by sutures It is technically difficult and leaking from the stoma is apt to occur It is rarely performed now Radio graphically the stomach is seen to be truncated and the gastric contents to pass from its most dependent portion into the duodenum The stomach is dragged to a varying extent to the left The degree of control of efflux is dependent on the amount of contracture at the anastomosis

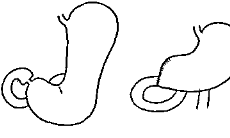


Fig 110 —Billroth I partial gastrectomy

Kocher s Operation is similar to the Billroth I except that in it the gastric stump is closed and the cut end of the duodenum is anastomosed terminally with the posterior surface of the stomach *Cuneo* illustrates an example in which the radiographic appearance is that of a conical gastric stump with the duodenum joined to its end The appearance is substantially the same as in the Billroth I Gastric evacuation was rapid in this case

Schoemaker s Operation —This is a partial gastrectomy leaving a long tongue of the greater curve to allow of an end to-end anastomosis with the duodenum The diagram indicates the type of resection It is a modification of the Billroth I designed to over come the technical difficulties of the latter It was first de scribed by *Schoemaker* of The Hague in 1921 and an excellent account of sixty eight cases has been published by *Morley* and *Roberts* (Fig 111)

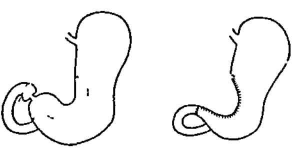


Fig 111 Schoemaker s operation

The X ray feature of note in cases after a Schoemaker operation is the gradual *restitutio ad integrum* in the gastric contour The food passes more slowly out of the stomach than in a Polya or Billroth II but more rapidly than in the normal stomach After six months there may be surprisingly little deformity of the lesser curve a rather wide pyloric ring appears and the first portion of the duodenum may develop an almost normal bulb The pyloric antrum is naturally short and rather narrow in calibre

GROUP WITH ABOLISHED SPHINCTERIC CONTROL

This group comprises the majority of post-operative cases referred for X ray examination, including as it does gastro jejunostomy and the popular varieties of gastrectomy Incidentally it is the most difficult group to examine radiographically

POSTERIOR GASTRO-JEJUNOSTOMY

This is the operation of choice for simple pyloric obstruction and duodenal ulcer, and is probably performed more often than all the other gastric operations together The essence of it is to form a wide anastomotic opening between the jejunum *as close to the duodeno jejunal flexure as* possible and the posterior wall of the stomach (Fig 112) The anastomosis must of necessity be made through the posterior layer of *the lesser sac The pylorus is sometimes occluded*, *this* occlusion is often designed to be temporary, and by suitable choice of sutures the pylorus will become patent again six months after the operation

Fig 112 —Posterior *gastro jejunostomy*

The objects of the operation are to provide free drainage *of the stomach to allow alkaline regurgitation from the* jejunum and to prevent the passage of acid gastric contents over the pyloric or duodenal ulcer

There are certain surgical desiderata to be observed in the planning of the operation

(1) The stoma when made should be $2\frac{1}{2}$–$3\frac{1}{2}$ inches in length This large opening is chosen to allow for the considerable contraction which takes place *after the operation*

(2) The long *axis of the stoma should be roughly* vertical It may incline either to the right or left without detriment The usual inclination is from the right shoulder to the left hip, for reasons of technical facility

(3) The lower end of the stoma should be close to the most dependent portion of the greater curve, to prevent stasis in the stomach below the level of the stoma This latter, however, occurs only if the stoma be placed very high

(4) No more of the jejunum should be left between the duodeno jejunal flexure and the stoma than will allow an easy sweep downwards on the part of the jejunum between these points Too little " cloth " will produce dragging on the flexure, whilst a redundant loop may promote stasis in the proximal limb

NORMAL RADIOLOGICAL APPEARANCES

In the erect position the prominent feature is the immediate passage of the opaque medium into the jejunum This occurs as soon as the patient swallows a mouthful or so *No more should be given in the first instance, as the initial* study of the relief pattern of the stomach, stoma, and jejunum is *important*.

If then the patient takes the remainder of a 12–14 oz barium meal some fleeting complete filling of the stomach may take place, but more commonly an irregular partial filling only is achieved the barium pouring into the efferent loop of the jejunum in a steady stream (Fig 113) The greater curve above the stoma is frequently indented by the mucosal folds resulting from the muscular contractility of the stomach During this stage the stoma itself is hidden in the antero posterior view

Fig 113 —Normal posterior gastro jejunostomy immediately after the meal

The pyloric antrum distal to the stoma rarely fills to any extent even if the pylorus has not been occluded e g in a case of duodenal ulcer As a rule a few irregular streaks of barium are all that are seen in this portion Sometimes it is better filled and some of the barium cream passes through the pylorus and duodenum but even then the pyloric antrum tends to be conical and lacks its normal rounded contours If the pylorus has been occluded the filling of the pyloric antrum is very poor indeed

The stoma may be seen in profile in a lateral view but for technical reasons it may be difficult to obtain a sharp radiogram of it in this position

The efferent jejunal loop and the upper few coils of jejunum are usually somewhat distended with barium and a mild permanent dilatation of the upper jejunum is normal It may be considerable The feathery appearance resulting from the valvulae conniventes persists but to a less extent than in the normal as a result of this dilatation

As a rule little or none of the meal passes into the afferent loop via the stoma with the patient in the erect position Any barium present in it and in the duodenum will usually have found its way through the pylorus

The rate of emptying is remarkably rapid in the writer's experience Various authorities have given the time for complete emptying as one to two

hours, and even more These figures may be true if by "emptying" is meant the complete evacuation of every trace of barium from the stomach, but not if the main mass of barium is referred to The main bulk of the opaque meal may have passed out into the jejunum in ten to fifteen minutes, and yet traces of barium remain entangled in the mucosal folds for an hour or two (especially in the folds of the pyloric antrum) Disregarding these entangled residues, the stomach is empty in from seven to thirty minutes, if the stoma be of average size With a large stoma these limits are shortened, and with a small one they are increased

Duval and his co workers state that although there may be rapid emptying for a time after the operation eventually, if the operation is successful, the stoma acquires some measure of sphincteric control, and the rates of gastric evacuation are only a little less than those of the average intact stomach

There is no doubt that the rate of evacuation in gastro jejunostomy gradu ally slows down with the passage of months or years To account for this by postulating a true sphincteric action is to attribute to the stomach a remarkable metaplastic power, that of growing a circular ring of muscle fibres round a wound in its wall, and developing a reflex nervous arc to control it This seems scarcely within the bounds of improbable possibility A more reasonable explanation would be the gradual contraction of the circular submucous scar resulting from the incisions, with consequent narrowing of the stoma

The more marked degrees of slowing of the gastric evacuation—up to several hours—are in most cases due to post ulcerative stenosis of the stoma

The rate of emptying of the stomach is modified by posture In the supine position a pool in the fundus may remain for a time, being there below the level of the stoma No lengthy stasis occurs however, because of the contractile tonus of the stomach

As the stomach empties its contents, the mucosal pattern of and round the stoma again makes its appearance, and may again be studied fluoroscopically and in radiograms

Tenderness on pressure over the stoma and elsewhere is an important diagnostic feature and careful search for such tender points should always be made

If the stomach before the operation was grossly dilated and atonic, and its muscle coats too atrophied to be restored to the normal, the radiographic picture after gastro jejunostomy will be somewhat modified Some dilatation will remain, the indentations of the greater curve will be less and there will be a tendency to pool formation in the pyloric antrum below the stoma The main mass of the barium cream will, however, pass rapidly into the jejunum

Pressure Control of the Efferent Loop

It is obvious from the normal appearances, without control, that the demonstration of recurrent duodenal and pyloric ulcer, and to a less degree lesser-curve ulcer, may be difficult on account of incomplete filling of the stomach.

Efficient obstruction of this loop enables the contrast medium to be dammed back in the stomach and a study of these portions to be made. Using an apparatus such as is described above, the lesser curve can be examined in its entirety. The prepyloric region is sometimes filled to its normal contours but more frequently remains to some degree contracted and conical. If the pyloric canal be not obstructed or occluded, the meal can be forced through it into the duodenal bulb. It is of importance here to know beforehand whether the pylorus was occluded at the operation or whether it was already stenosed. The duodenal bulb does not usually fill out to normal contours, partly because it is difficult to force a sufficiently large amount of barium through the pylorus at a time and partly because some scarring of the bulb may persist after the healing of a duodenal ulcer.

THE COMPLICATIONS OF POSTERIOR GASTRO-JEJUNOSTOMY

Tabulated below are the normal and abnormal results in 150 consecutive barium meal examinations of posterior gastro jejunostomy. They are drawn from the X ray departments of two London hospitals and private practice, and represent cases operated on by many different surgeons. That is to say they do not represent the surgery of those two hospitals but rather an average sample from most of the surgical centres of London and some of the provinces.

POSTERIOR GASTRO JEJUNOSTOMY 150 CASES

Normal		23
Dumping stoma		12
Inflammatory sequelæ		
Gastritis	4	
Gastro jejunitis	19	
Jejunitis	17	
	—	40
Ulcerative sequelæ		
Recurrent duodenal	25	
Recurrent lesser curve	16	
Jejunal	11	
Recurrent posterior wall	6	
Recurrent pyloric	2	
Stomal	3	
	—	63
Gastro entero-colic fistula		3
Stenotic sequelæ		
Stenosis of stoma	22	
Obstruction of stoma	9	
Stenosis of efferent limb	5	
Stenosis of afferent limb	5	
Duodenal ileus	6	
Jejunal ileus	2	
Contracture of pyloric antrum	3	
Pyloric stenosis	1	
	—	53
High mal placed stoma		2
Carcinoma supervening		2
Retrograde jejuno gastric intussusception		1
Total		199

The number of abnormal results found by examination exceeds considerably the total number of cases as in many cases more than one abnormality was found e g recurrent duodenal ulcer and jejunitis

Verification of the abnormal results by operation has been possible in a small proportion of cases only owing to a wise reluctance on the part of surgeons to operate on these cases a second time but the more serious of the complications are only too certain radiographically Amongst such may be mentioned recurrent ulceration and the grosser forms of stenotic sequelæ In the milder abnormalities such as dumping stoma slight stomal stenosis slight gastro jejunitis a personal factor may allow some error to creep in in differentiating the abnormal from the normal but these are of little consequence compared with the others

Jejunal Dumping (*Syn* dumping stoma overloading of the jejunal loop)

This is a fairly common sequela If the stoma be very large the flooding of the jejunum is exaggerated and the stomach may empty into it in two to three minutes The patient experiences a dragging fullness and discomfort immediately after food and the jejunum is seen to be distended and overloaded temporarily Dietetic indiscretions either of quality or of quantity increase the patient s discomfort It is reasonable to explain the symptom complex on these mechanical grounds To what extent jejunal overloading contributes to the development of jejunal ulcer is a moot point and one difficult to put to the test

Gastritis

The presence of this condition is difficult to establish radiologically in the absence of an associated jejunitis unless it is gross in degree

The commonest type is a peri anastomotic hæmorrhagic gastritis a condition frequently leading to stomal ulceration

The difficulty lies in the increase in the rugæ folds which usually occurs in a successful uncomplicated gastro jejunostomy so that unless the jejunum is also implicated this condition should be diagnosed radiographically only if there is gross increase in the size of the rugæ and marked spastic reaction on the greater curve

Jejunitis

The barium in a normal loop of jejunum shows a feathery or granular distribution with fine subdivisions due to the valvulæ conniventes In the normal jejunum immediately distal to a gastro jejunostomy some alteration in the appearance results from the overloading of the gut The valvulæ conniventes are still clearly seen as thin knifelike intersections in the barium mass Jejunitis is a not uncommon sequela of gastro jejunostomy especially in cases of marked

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hyperchlorhydria It may exist with or without gastro jejunal or jejunal ulcer, but is an invariable accompaniment of the two latter The radiographic appearance is typical and can be readily pictured from an appreciation of the pathological changes (Fig 114–116) The jejunal mucosa becomes hyperæmic and œdematous and the plicæ markedly thickened The barium filled jejunal

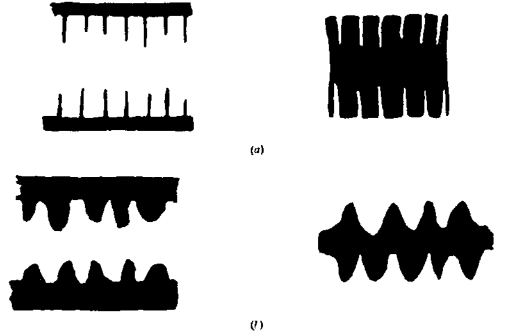


Fig 114.—Diagram to show the wall of the jejunum and its barium filled lumen in (a) the normal and (b) jejunitis

lumen as a whole is narrowed and presents instead of the normal fine tooth comb serrations a series of wide rounded or jagged indentations due to the thickened plicæ This deformity shows a constant contour in a series of pictures—an important diagnostic point Tenderness on radioscopic palpation over it is present in the great majority of cases

Persistent or Recurrent Peptic Ulceration

This may be gastric pyloric duodenal gastro jejunal or jejunal in site

GASTRIC ULCER —*Lesser-curve ulcer* is as a rule easily demonstrated if the stomach be reasonably well filled By controlling the efferent loop a niche will be made visible with greater certainty and on the greater curve a localised exaggeration of the notching which is usually present The same applies to an ulcer on the *posterior wall*

DUODENAL ULCER presents a more difficult problem, even more difficult than in the case of a duodenal ulcer which has recurred after medical treatment

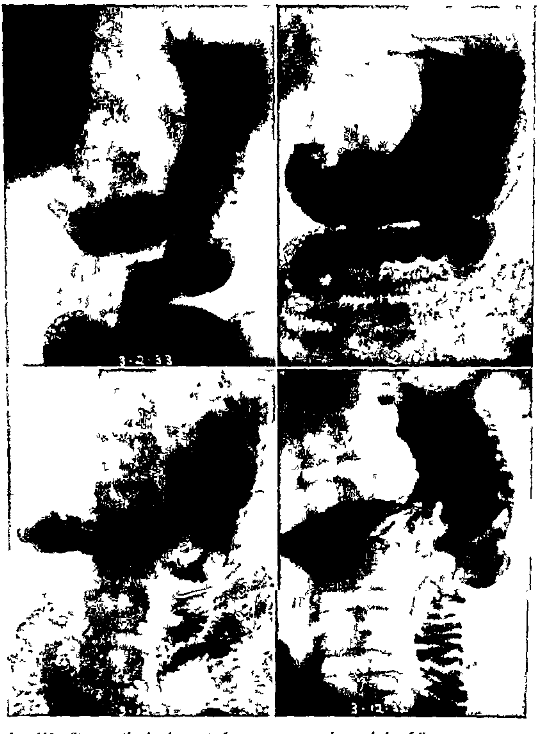


Fig. 11[illegible].—Stages in the development of gastro-jejunitis and jejunal ulcer following on posterior gastro-jejunostomy.
Note also the development of a gastric diverticulum near the cardia.

In the latter only the deformity due to scarring has to be discounted After jejunostomy, however, the further disturbing factor of incomplete or non filling of the cap must be taken into account In some cases the actual ulcer crater may be seen, but more frequently only some general deformity of the duodenal bulb is present

If the jejunum has been satisfactorily occluded by a truss and food is passing freely through the pylorus the second disturbing factor can be excluded, and the problem becomes that already described under the section of duodenal ulcer

Fig 11f —Gross gastro jejunitis following posterior gastro jejunostomy showing the narrowed rigid jejunum with oedematous plicae

Pyloric Ulcer is readily demonstrated, provided opaque food can be made to pass through the pyloric canal

Gastro jejunal Ulcer —If the stoma on the posterior wall is hidden in the postero anterior view, a stomal ulcer may show only in a relief pattern radiogram Frequently, however, associated spasm and cicatricial contracture bring the anastomosis into profile in the postero anterior view, and so render visible an ulcer in this situation If it be large it may be visible in profile in a lateral view Owing to the normal irregularity in the contours in a healthy stoma care must be used in diagnosing an ulcer crater from a projecting rugal crevice Further confirmatory signs may help The most important of these is pain on pressure localised over the stoma Another sign of value is a persistent residue in the ulcer crater after the stomach is empty Such a residue must, however, be differentiated from flecks entangled in the mucosal folds in this region

Jejunal Ulcer —If this be close to the stoma, the above remarks will apply If it occur below the level of the greater curve there is every chance of the ulcer crater being outlined at some stage of the examination

Again care must be taken not to mistake a fleck of barium entangled in the mucosa for a barium filled crater The larger, the denser and the more persistent a residue, the more likely it is to be in an ulcer crater (Figs 117–118) As in ulcer craters elsewhere in the alimentary canal, the absence of peristalsis in the crater promotes sedimentation of barium in it and so causes a dense opacity therein Localised tenderness to pressure of one finger over the residue is an important confirmatory sign The valvulæ conniventes seen in relief pattern converge to and are interrupted by the crater, an appearance best seen if the latter is on the anterior or posterior wall and so viewed *en face* An associated jejunitis is almost always present, and in the absence of this *great* reserve should be exercised in diagnosing stomal or jejunal ulcer

Fig 117 —Jejunitis and jejunal ulcer following posterior gastro jejunostomy

GASTRO JEJUNO COLIC FISTULA is a not uncommon complication of jejunal ulcer, resulting from perforation of the ulcer into the transverse colon It is described in the *section on the stomach* (Fig 119)

Fig 118 —Gastro jejunitis and jejunal ulcer following posterior gastro-jejunostomy

Narrowing of the Stoma

The usual surgical practice nowadays is to make a wide stoma to allow for gradual contraction If this contraction is greater than usual the rate of gastric evacuation is slowed To what extent this narrowing and consequent slowing is disadvantageous is a matter of doubt The wide stoma, while it achieves

its results so far as drainage is concerned, alters the normal physiological processes profoundly, and frequently causes jejunal overloading Narrowing of the stomach sufficient to slow the rate of emptying of the stomach to between one and one and a half hours is probably not undesirable but retention in the stomach up to two three or more hours should be regarded as a sequela likely to defeat the objects of the operation In such cases the stenosis of the stoma cannot usually be demonstrated directly In the majority of cases its presence can be deduced only by the slow rate of emptying

FIG 119 Gastro jejuno colic fistula demonstrated by a barium enema a sequela of posterior gastro jejunostomy and jejunal ulceration

Some *contraction* of the stoma after a year or so is a normal occurrence but the common cause of marked narrowing of the stoma is cicatrisation after ulceration This produces varying appearances according to the exact site of the stenosis Reference to the diagram (Fig 120) indicates the possibilities in this respect

No 1 Represents the normal

No 2 Stenosis of the stoma, the pylorus and jejunal loop remaining patent Gastric evacuation takes place as in the intact stomach, via the pylorus and duodenum Some puckering in the region of the stoma is usually present

No 3 Stenosis of pylorus and stoma This results in gastric dilatation and stasis

No. 4. Stenosis of the stoma and afferent jejunal limb. As a result of this, gastric dilatation and stasis take place, and, in addition, duodenal ileus.

No 5. Stenosis of the efferent jejunal limb alone. The results are precisely *the same as in No. 4*

No. 6. Stenosis of the afferent jejunal limb alone Gastric evacuation

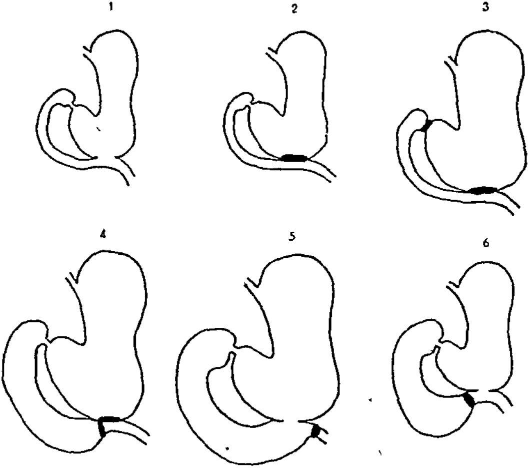


FIG 120.—The stenotic complications of posterior gastro-jejunostomy. For the sake of clarity the stoma is shown on the margin of the stomach

1 Normal 2 Obstruction of stoma 3 Obstruction of pylorus and stoma 4 Obstruction of stoma and afferent limb 5 Obstruction of efferent limb 6 Obstruction of afferent limb only

occurs through the stoma as in a normal gastro-jejunostomy. If any appreciable amount of food passes through the pylorus, duodenal ileus may result.

Contracture of the Pyloric Antrum

The pyloric antrum usually assumes a more or less conical shape after gastro-jejunostomy. This may be regarded as the result of disuse. Marked

contracture, narrowing the lumen down to the thickness of a lead pencil may result from spasm interstitial fibrosis, and epigastric adhesions In these cases it may be impossible, except by laparotomy, to exclude the presence of a supervening carcinoma particularly if anæmia achlorhydria, and anorexia are present as they sometimes are

Malposition of the Stoma

It is only when this is gross that serious consequences result Minor variations in the site of the stoma are of no importance If however the stoma is

FIG 121 —Posterior gastro jejuno tomy with obstruction of the stoma and pylorus Gastrectasia obstructive hyperperistalsis and gastric stasis are characteristic features

FIG 122 —Old gastro jejunostomy for duodenal ulcer with stenosis of the stoma and afferent jejunal limb recurrent duodenal ulcer gastritis and obstructive ileus of the duodenum

very high in the stomach satisfactory drainage may not occur and the object of the operation be not achieved The writer has met one such case The gastric stasis present in this case was obviated by posture when the patient lay down the stomach emptied satisfactorily

Duodenal ileus may result in a minor degree from a high stoma especially if a visceroptosis of some degree be present In such case if the duodenum and duodeno jejunal flexure be ptosed below the level of the stoma the stomach may empty itself partly into the afferent jejunal loop and so into the duodenum This sequence of events is visible fluoroscopically On the patient swallow

ing a mouthful of barium, some is seen to pass into each loop of the jejunum, that going into the afferent collecting in a pool in the dependent part of the dilated duodenum This is seen only in the erect position The supine or prone position removes the static factor which is the essence of the abnormality

Retrograde Jejuno-gastric Intussusception

This is a rare complication of gastro jejunostomy It may be acute or chronic The acute cases, of which the records of thirty five cases have been

FIG 123 —Posterior gastro jejunostomy followed by gross stenosis of the stoma and afferent limb gastrectasia and marked duodenal ileus

FIG 124 —Vicious circle Old gastro jejunostomy *followed by stenosis of the stoma* To relieve this a second anastomosis was made later between the efferent limb and the upper *part of the stomach* The *meal passed out of* the lower stoma up to the upper, and back into the stomach again

collected by *Adams* are urgent surgical emergencies, precluding any radiological investigation

Ledoux Lebard and *Garcia Calderon* note the X ray appearances in two chronic cases The intussusception produced a mobile rounded filling-defect and the relief pattern of the tumour showed striations due to the jejunal plicæ

The writer has seen two cases of intermittent jejuno gastric intussusception *showing these signs In one the tumour was seen end-on, and the striæ* circular in disposition (Fig 125) At operation the intussusception had

Fig 125 —Chronic retrograde jejuno gastric intussusception following posterior gastro jejunostomy

reduced itself and only a dilated jejunum was found The second has not been operated upon

Anterior Gastro Jejunostomy

In this a long loop of jejunum is brought up in front of the transverse colon and anastomosed to the anterior gastric wall (Fig 126) It is performed *faute de mieux* when a gastro-enterostomy is essential and it is technically impossible to adopt the posterior method The stoma is made as near as possible to the pylorus and greater curve and its axis should run from above downward and to the right Because of the serious risk of stasis in the long afferent loop—about 18 inches in length as a rule—an additional jejuno jejunostomy is frequently made between the two loops

The X ray appearances in anterior gastro jejunostomy are substantially the same as those in the posterior operation except that in the lateral view the stoma and jejunal loop are visible anterior to the stomach and two jejunal limbs afferent and efferent are often outlined below the stomach If the operation be successful only the efferent loop should fill but frequently food also passes into the afferent When this occurs to excess a vicious circle is established and the dilated overloaded proximal loop is at once apparent radiographically Jejuno jejunostomy completely relieves the condition but short circuits the alkaline duodenal juice from the stoma and so promotes the formation of anastomotic and jejunal ulcer

The other untoward sequelæ of anterior gastro jejunostomy are similar to those in the posterior method

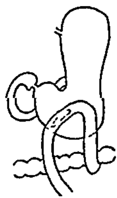


Fig 126 —Anterior gastro jejunostomy

Finney s Pyloroplasty

This operation is not much used in this country It is performed in cases of pyloric and juxta pyloric duodenal

ulcer The second portion of the duodenum is mobilised and anastomosed with the anterior wall of the stomach, close to the greater curve in the pyloric third The stoma runs into and includes the pyloric canal and the ulcer and scar tissue are excised if possible (Fig 127) In theory the operation is a good one as it allows free drainage and acid neutralisation

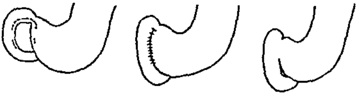


FIG 127 —Finney's pyloroplasty

Radiologically the meal is seen to pass freely into the duodenum no pyloric canal or duodenal bulb being present The junction of pyloric antrum and duodenum is as a rule markedly irregular in contour The rate of gastric evacuation is not so rapid as in the average gastro jejunostomy

Marginal ulcer is said to be a rare sequela, but some cases develop adhesions dragging the stoma up to the liver and necessitating subsequent gastro jejunostomy

BILLROTH II PARTIAL GASTRECTOMY

In the past a popular operation for carcinoma of the stomach or large chronic ulcers in the region of the lesser curve this operation is to some extent being superseded by the Polya types of gastrectomy It consists of segmental resection of the stomach including the pyloric canal closure of both ends, and posterior gastro jejunostomy (Fig 128)

FIG 128 —Billroth II partial gastrectomy

Radiologically the stomach behaves similarly to the jejunostomised stomach save that the pyloric antrum is absent At first the gastric stump is small but later it enlarges somewhat This dilatation is not marked unless contracture of the stoma takes place The right blind extremity of the stomach assumes a rounded slightly puckered contour The stump can best be seen if the efferent jejunal loop be obstructed by a truss Only then can the stump be properly filled and its contours studied

Normally there is no reflux from the stomach into the afferent loop and duodenum But efficient obstruction of the efferent loop by a truss will cause such reflux an appearance which must not be mistaken for a vicious circle It disappears on removal of the truss

Complications of the Billroth II Gastrectomy

RECURRENT GASTRIC, STOMAL, OR JEJUNAL ULCER is less common than in gastro jejunostomy, as a considerable proportion of the enzyme-producing mucosa is removed by the operation The more complete the gastrectomy, the less chance of recurrent peptic ulcer As, however, this operation does not allow of a very wide resection, recurrent ulceration does occasionally recur, and its radiographic demonstration and appearances are similar to those in gastro jejunostomy

IN CASES OF CARCINOMA VENTRICULI, local recurrence of the growth is not uncommonly met with Depending on the precise site of the recurrence, there may result

(1) *Obstruction of the Whole Stoma* —This causes dilatation of the fundus and œsophagus, and, clinically, vomiting and rapid starvation The nature of the condition is clearly visible on fluoroscopy and the details of the gastric filling defect in serial radiograms Discounting the distortion due to the suture line, a recurrence causing the above interference with the stoma usually presents a constant filling defect which is fairly characteristic

(2) *Obstruction of the Efferent Loop Alone* —The stomach will present similar appearances but in addition the duodenum will be in a state of ileus, and be outlined by the barium cream passing from the afferent limb into it

(3) *Obstruction of the Afferent Loop Alone* —Again a duodenal ileus results, but as no barium can pass into it it will be demonstrable radiographically only if it contain gas

THE POLYA PARTIAL GASTRECTOMY

Polya-Moynihan Partial Gastrectomy (*Syn* Anterior left right Polya) —This modification of the original Polya operation is probably more frequently adopted in this country than any other form of partial gastrectomy It consists of a segmental resection of the lesion bearing portion of the stomach, including the pylorus, as in the Billroth II, with end to side anastomosis of the gastric stump to a loop of jejunum In the original Polya the jejunum was brought up through a fenestra in the transverse mesocolon This is said to have the disadvantage in cases of carcinoma that a recurrence, apt to take place near the fenestra.

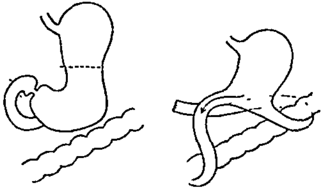


FIG 129 —Anterior L → R Polya Moynihan partial gastrectomy

may cause obstruction of the jejunum It is avoided by the Moynihan modification, in which a loop of jejunum is carried up in front of the transverse colon Fig 129 indicates the direction of the jejunal current (from left to right) The loop is chosen as near to the duodeno jejunal flexure as possible allowing enough length in the afferent limb to prevent any possibility of tension on it when the patient assumes the erect position

Polya-Balfour —In Balfour's modification the long jejunal loop is used and the jejunal current is in the reverse direction to that in the Polya Moynihan In order to prevent stasis in the proximal limb a lateral anastomosis is made between the two limbs of the loop (Fig 131)

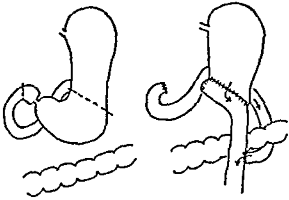


Fig 130 —Modified Polya partial gastrectomy With anastomosis in Y

Modified Polya, with Entero-anastomosis in Y —In this modification a segmental resection is made as before A jejunal loop is brought up as in the Polya Balfour, but is divided across The cut end of the distal limb is closed and that limb anastomosed side to end with the gastric stump The proximal jejunal limb is then anastomosed end to side with the distal limb an inch or two below the gastric anastomosis (Fig 130)

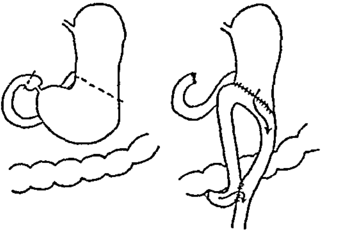


Fig 131 —Anterior Billroth II Polya Balfour partial gastrectomy with long jejunal loop and entero anastomosis

X-ray Appearances in the Polya-Moynihan Partial Gastrectomy

The gastric stump is as a rule smaller than in the Billroth II operation, and the anastomosis is seen to be terminal To study the full contours of the stump control of the efferent loop will be necessary, but this should be preceded by observation of the normal emptying (i e without control)

Under the screen careful note should be made of the efflux into the jejunum The barium should be seen to pass chiefly into the efferent limb at the right of the stump Some will pass into the left or afferent limb but this should not be excessive

With control of the efferent limb the fundus of the stomach should fill out to a normal contour and there may be some œsophageal reflux The afferent jejunal limb will fill more definitely and active peristalsis will be seen as this loop endeavours to empty itself The contours in the region of the anastomosis vary considerably depending on the precise position of the suture A certain amount of puckering is to be expected

The stomach after this operation empties very rapidly by the time the patient has finished drinking a 12 oz meal most of it will be in the jejunum and mild jejunal overloading is a common effect of rapid ingestion Occasionally it may be marked causing a sensation of fullness and dragging in the abdomen It is therefore important that a patient should masticate thoroughly and eat and drink slowly after having been subjected to this type of operation

Ravdin Pendergrass Johnston and *Hodes* in a paper stressing the effect of different foodstuffs on the rate of gastric evacuation state that this obtained also in the stomach after a Polya gastrectomy and that marked delay can occur after ingestion of fats even if the stoma is large Such slowing of the rate of evacuation as occurs is the result of diminished gastric tone and peristalsis but in the writer s experience the effect of gravity and the fact that the bottom has literally been cut out of the stomach result in rapid evacuation even when the contrast meal does contain carbohydrates and fats

Abnormal After-results

RECURRENT PEPTIC ULCER —This an uncommon sequela may be gastric stomal or jejunal in site The more complete the gastrectomy the rarer is such a complication Recurrent gastric ulcer may be on the lesser curve when it will show as a niche or on the posterior wall In the latter case a relief picture is the best means of demonstrating it

Stomal ulcer is more easily demonstrable after the Polya type of operation as the stoma is terminal relative to the stomach As with other forms of stoma residues entangled in puckered mucosa must be differentiated from a barium filled ulcer crater The latter are more constant in a series of pictures and if the ulcer be deep denser from sedimentation therein Tenderness on localised pressure over the suspected shadow is an important confirmatory sign

Jejunal ulcer is more readily visible than in cases of gastro enterostomy as the gastric shadow is not superimposed on the juxta stomal portion

OVERLOADING OF THE PROXIMAL LIMB —This rarely occurs in the Polya Moynihan operation if the afferent jejunal limb be short and the axis of the stoma properly planned but with a vertically disposed stoma and an unduly long limb some stasis and ileus may be seen It does however occur in

RECURRENT CARCINOMA if the efferent limb be obstructed by the recurrence Clinically such cases present characteristic features—inability to eat or drink any but small amounts persistent vomiting epigastric pain and wasting Radiographically a gastric filling defect near the efferent stoma may be present Œsophageal reflux and dilatation may occur and the meal is seen to distend the afferent limb (Fig 132) The rate of gastric evacuation is slow unless by vomiting

FIG 13 —X R → L anterior [illegible] of a partial gastrectomy for carcinoma with recurrence obstructing the efferent jejunal limb and ileus of the afferent

Recurrent carcinoma of the gastric stump itself is apt to cause stenosis at or just above the stoma Clinically the symptoms are as above described and radiographically a considerable filling defect of the stump will be apparent

Scarring from recurrent simple ulceration may also cause obstruction of the stoma or either jejunal limb efferent or afferent with similar appearances to those in the carcinomatous variety save that there will not be present a gross filling defect of the stump itself

X ray Appearances in the Polya Balfour and Polya in Y Operations

The appearances will vary from those above described chiefly in the site of the efferent jejunal limb which is situated at the left angle of the stump In the Balfour modification some barium may pass into the afferent loop but this can cause no trouble because of the jejuno jejunostomy below In the in Y type again no over loading of the afferent limb can occur With these exceptions the abnormal after-effects are similar to those described in the case of the Polya Moynihan

POLYA WITH RESTRICTED STOMA POLYA LAKE POLYA-FINSTERER

The Polya-Lake modification judging by the radiographic appearance controls the efflux of the gastric contents better than any other of the Polya type In addition to preventing dumping into the jejunum it renders reflux into the efferent loop very improbable

In it a short jejunal loop is brought up through the transverse mesocolon the jejunal current flowing from right to left Although the jejunal loop is

sutured along the whole length of the cut gastric stump only a small stoma about 1½ inches in length is made at the lower end (Fig 133)

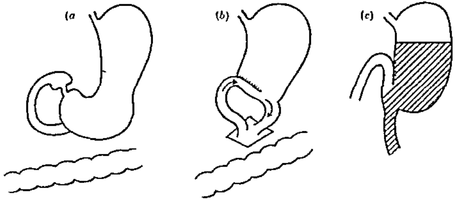


Fig 133—The Polya Lake partial gastrectomy (a) The resection (b) The anastomosis (c) The radiographic appearance

Finsterer s modification is in essence the same

Radiological Features—The gastric stump fills reasonably well in the

Fig 134—Normal radiographic appearance after the Polya Lake partial gastrectomy

erect position and the stoma is clearly seen at the lower pole The right border of the stump is formed by the remaining portion of the lesser curve and

the sutured end of the stump above the stoma This largely loses its initial angularity and becomes more or less straightened out At the junction of the two there is apt to remain a dimple which must not be mistaken for a recurrent lesser curve ulcer The greater curve of the stump balloons out to form quite a respectable lower pole (Fig 134)

Recurrent inflammatory and ulcerative sequelæ are very rare after this operation *Lake found three cases of jejunal ulcer in 300 patients subjected to* the operation

The valuable feature of this operation is the restriction of the size of the stoma which leads to gradual expansion of the gastric stump and the formation *of a satisfactory gastric reservoir*

The position which the suture line assumes after the operation (it forms virtually a new lesser curve) is of importance in the technique The anastomosis must be of the right → left variety The effect of the stoma restriction

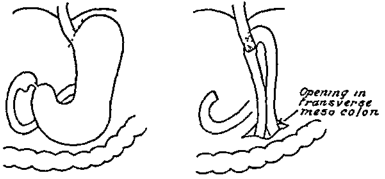


FIG 13 —Complete gastrectomy (*a*) The resection (*b*) The completed operation

in preventing reflux into the afferent limb has precisely the reverse effect if the stoma is restricted in a left → right anterior Polya Moynihan In this case the gastric contents are inevitably shot into the afferent limb and a vicious circle results

COMPLETE GASTRECTOMY (MOYNIHAN)

This, a difficult operation technically, and attended by an appreciable immediate mortality, is indicated in some cases of gross scirrhous carcinoma of the leather bottle type It consists of resection of the whole stomach and end in side or side to side anastomosis of the lower end of the œsophagus with a high loop of jejunum The latter is brought up through a fenestra in the transverse mesocolon The two limbs of the jejunum may be anastomosed lower down to short circuit the bile and pancreatic secretions (Fig 135)

Early X-ray Appearances after Complete Gastrectomy

Of two cases examined by the writer one was performed accord[illegible] to the above technique In it, one month after the operation the anasto

had already begun to dilate and to form a pseudo fundus (Fig 136) In the other case the cut end of the œsophagus was anastomosed to the pyloric antrum close to the pyloric canal A month after the resection the lower œsophagus had begun to dilate and take over the duties of reservoir An interesting point in the second case was that the pylorus remained widely open, doubtless from the destruction of its sphincteric reflex nervous control

FIG 136 —Appearance of the anastomosis one month after complete gastrectomy

Late X-ray Appearances after Complete Gastrectomy

Butler has described the appearances in a case six months after complete gastrectomy The feature in it was a considerable dilatation of the jejunum close to the œsophageal stoma The dilated portion was ballooned into the left dome of the diaphragm contained a gas bubble, and simulated the fundus of a normal stomach Doubtless the constant upward pressure of gas in this loop contributed to this effect Barium remained in this dilated pseudo fundus for more than five minutes At the end of an hour all the barium had accumulated in the pelvic coils of the ileum Transit is therefore rapid, as in the partial gastrectomy cases

CHAPTER XIV

THE DIAPHRAGM

In this section the diaphragm in relation to the abdomen will be considered

Anatomy—The diaphragm a dome shaped musculo aponeurotic partition between the thoracic and abdominal cavities is composed of a central trefoil shaped tendon, and surrounding it a peripheral sheet of radiating muscular *fibres* *The muscular fibres are all inserted into the central tendon, and take* their origin from the following points

(1) Anteriorly by two fleshy slips from the back of the ensiform cartilage

(2) On either side from the ribs and costal cartilages, interdigitating with *the transversalis abdominis*

(3) Postero laterally from aponeurotic arches the ligamenta arcuata

(4) Posteriorly from the lumbar vertebra by two crura These crura arch over the aorta to form the aortic opening decussate and separate to form the *œsophageal opening, and then fuse with the central tendon*

On each side there are two gaps in the diaphragmatic attachment of importance in diaphragmatic herniæ—the foramen of Morgagni between the sternal and costal attachments and the costo lumbar angle the site of the *embryonic pleuro peritoneal hiatus*

The diaphragm presents three main openings Two have already been mentioned both again of importance as hernial sites The third the foramen for the inferior vena cava, pierces the central tendon in front and to the right of the *œsophageal opening*

Inferior Relationships—The right dome of the diaphragm is accurately moulded over the convex surface of the right lobe of the liver, the right kidney and the right suprarenal capsule, the left dome over the left lobe of the liver, the *gastric fundus the spleen the left kidney and left suprarenal* capsule

NORMAL RADIOLOGICAL APPEARANCE OF THE DIAPHRAGM

The domes of the diaphragm appear in a postero anterior radiogram or on fluoroscopy as smooth rounded contours stretching from the cardiac shadow to the ribs laterally The junction with the cardiac shadow is at about a right angle Sometimes the angle is a little more obtuse sometimes more acute

The *costo phrenic angles laterally are clear cut and very acute in expira*tion They open up but remain pointed on forced inspiration

Frequently the domes show a slightly wavy contour, due to the muscular bands of the diaphragm producing shallow ridges

The right dome is usually about a centimetre higher than the left due to the larger mass of the right lobe of the liver

Movements of the Diaphragm —The respiratory excursion of the diaphragm during quiet breathing is 1–2 cm In forced respiration it may be 2 6 cm or more It is greater in abdominal breathing than in thoracic Viewed in the postero anterior plane the descent of the diaphragm is seen to consist of a lowering of the central tendon to some extent while the two domes as they descend become flattened and thus show a greater range of movement than does the central tendon The latter is to some extent anchored by the heart and pericardium

In the lateral view the posterior attachment of the diaphragm is seen to be about 3 inches below the anterior The anterior portion beneath the heart is roughly horizontal and the diaphragm slopes down increasingly as it is traced backwards The posterior part shows a greater respiratory travel than the anterior

IRREGULARITIES IN THE DIAPHRAGMATIC CONTOUR

The commonest is upward displacement of one or both domes Upward displacement of the whole diaphragm occurs from any increase in the intra abdominal tension Tympanites from any acute illness has this result In ascites it occurs to a marked degree Pregnancy large ovarian cysts or indeed any large abdominal tumour will cause it

Upward Displacement of One Dome —The causes of this are many—intrathoracic diaphragmatic and intra abdominal The intrathoracic causes are dealt with in their appropriate sections

Of the diaphragmatic and abdominal causes the following call for mention

(1) Diaphragmatic hernia This although not a true upward displacement raises the radiographic contour and is conveniently grouped here

(2) Phrenic nerve paralysis

(3) Eventration

(4) Temporary distension of the gastric fundus by air

(5) Subphrenic abscess

(6) Subhepatic abscess

(7) Enlargement of either lobe of the liver from neoplasm liver abscess hydatid cyst etc

(8) Gross enlargement of the spleen

(9) Large renal tumour which raises the posterior part of the diaphragm

DIAPHRAGMATIC HERNIA

Embryology

For a proper understanding of the congenital types of diaphragmatic hernia some appreciation of the development of that structure is necessary

In the early embryo the pleural cavities protrusions of the primitive

cœlom, communicate freely with the peritoneal cavity The diaphragm which eventually separates them is a composite structure embryologically (Fig 137)

The *ventral half is formed from the septum transversum*, a mesodermic partition separating the heart from the abdominal viscera It first lies obliquely in the neck, but gradually moves down and assumes a transverse disposition It reaches its final position opposite the level of the 12th rib at about the fourth week In its descent it carries with it its nerve supply from C 3, 4, and 5 the phrenic nerve The point of entry of the latter into the adult diaphragm marks the posterior limit of the portion formed from this septum

The posterior half of the diaphragm is formed from three structures the primitive *mesentery of the foregut* stretching between the dorsal cœlomic wall behind and the septum transversum in front , and the pleuro peritoneal folds, one growing inwards from each lateral cœlomic wall to fuse with the septum transversum and the medial mesentery The last portion to fuse is the postero lateral, where for a time there persists *on each side, the pleuro peritoneal canal or hiatus* Failure of this hiatus to close accounts for a common type of hernia

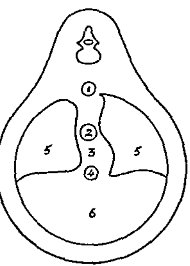


Fig 137 —Diagram showing the components which form the diaphragm

1 Aorta 2 Œsophagus 3 Medial mesentery 4 Inferior vena cava 5 Pleuro peritoneal folds 6 Septum transversum

Classification

The following classification is adapted from *Hume* By the term congenital is meant any *hernia which occurs through a region of the* diaphragm where there is a developmental hiatus or weakness i e in cases where there is a developmental explanation for the site of the herniation

CONGENITAL

(1) *Through the pleuro peritoneal hiatus*

(2) Through the dome

(3) Para œsophageal (*a*) Through the hiatus (*b*) Thoracic stomach (*c*) Non development of crura

(4) Through the foramen of Morgagni

ACQUIRED

(5) Non traumatic

(6) Traumatic (i e resulting from wounds)

Anatomical Features

(1) *HERNIA THROUGH THE PLEURO PERITONEAL HIATUS*—This hiatus is patent for the first three months of fœtal life It is situated between the costal

and spinal muscle fibres. At birth a fibrous area marks its site—the lumbo costal triangle close to the arcuate ligament. All stages of hiatal defect may exist from a small gap to almost complete absence of that half of the diaphragm. It is usually incompatible with life as herniation takes place when breathing is established and strangulation or paralytic ileus supervenes in a few hours or

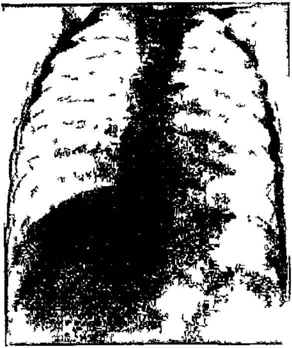


FIG. 138.—Congenital hernia of the stomach through a large right pleuro-peritoneal hiatus. Female 3 months admitted to hospital with broncho-pneumonia and intermittent attacks of vomiting.

At post mortem the stomach was in the right thorax but it slipped back into the abdomen. This explained the intermittent vomiting. The oesophagus was not shortened.

FIG. 139.—Herniation of the stomach through the right dome of the diaphragm.

days. These cases do not as a rule find their way into an X ray department. A plain radiogram of the chest may indicate the nature of the condition by the presence of gut and other viscera in the pleural cavity (Fig. 138). In the gross cases the condition may be associated with non rotation of the gut.

(2) HERNIA THROUGH THE DOME.—This occurs usually on the left side, the liver effectively protects the right dome. The evidence in favour of some of these cases being congenital is that several cases have been recorded in newborn infants. The gap in the dome varies in size but is fairly constant in

position, in the left trefoil of the central tendon, immediately behind the entry of the phrenic nerve into the diaphragm. It is explicable on the assumption that the pleuro-peritoneal membrane fails to unite completely with the septum transversum. It is a rare form of hernia. The stomach and a portion

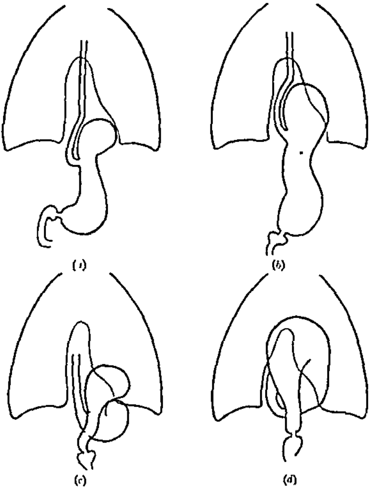


Fig. 140.—Para-œsophageal hernia of the stomach.
(a) Hernia of the fundus. (b) Hernia of the upper half of the stomach.
(c) Hernia of the pars media. (d) Hernia of the whole stomach.

of the colon are invariably herniated, and, when the gap is large, the spleen and portions of the small intestine also. Fig. 139 represents an unusual type, herniation of the stomach through the right dome.

(3) Para-œsophageal Hernia.—While herniation through the pleuro-peritoneal hiatus is the commonest type of diaphragmatic hernia found in the fœtus, these are usually incompatible with life, and in adults the para-œsophageal type is much the commonest.

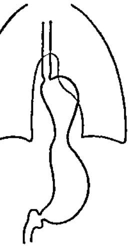


Fig 141 —Congenital partial thoracic stomach

Two types occur a *true herniation* through the œsophageal orifice, which may or may not be associated with incomplete development of the crura (Fig 140) and a partial *thoracic stomach* (Fig 141)

In the former type the gastric fundus is displaced upwards into the posterior mediastinum the œsophagus being of normal length and folded somewhat on itself In most cases the fundus is to the left of the œsophagus encroaching on the left pleural cavity In one of the writer s cases the herniation took place to the right side of the gullet

The partial thoracic stomach results from failure of that viscus to descend from the primitive thoracic cœlom with the descent of the septum transversum The forming diaphragm then traps a varying portion of the stomach above it The amount varies from almost the whole of the stomach to a small portion of the fundus The œsophagus is short to a degree corresponding to the position of the stomach The latter is somewhat constricted at the œsophageal opening the opening being larger than the normal but smaller than the full lumen of the stomach The distinguishing feature between this type and the true para œsophageal hernia is the short œsophagus

(4) Hernia through the Foramen of Morgagni —These are very rare The sac lies behind the sternum and may contain colon or small intestine Postero anterior and lateral views are necessary to demonstrate them (Fig 142)

(5) Acquired Non traumatic Hernia —These are rare and may occur in any part of the diaphragm except the central part of the tendon Their appearance depends on the precise site and degree The commonest site is through the left dome of

Fig 142 —Hernia of the stomach through the foramen of Morgagni (lateral view)
1 Stomach 2 Œsophagus 3 Diaphragm

the diaphragm They are regarded as non congenital in that they herniate through a part of the diaphragm which is not the site of a possible developmental fault or weakness

(6) TRAUMATIC HERNIÆ, i e herniæ following *on wounds of the diaphragm, were common during* and after the Great War Like the acquired non traumatic variety, they were commoner through the left dome of the diaphragm on account of the protective mass of the liver on the right

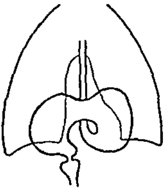


FIG 143 —Congenital complete thoracic stomach

COMPLETE THORACIC STOMACH — Numerous cases of this are now on record

R E Roberts has described a case in a female of 3 years and 10 months The œsophagus was short and the stomach bilocular Fig 143 shows the disposition in his case Three similar cases had been previously reported by *Bailey* and *Le Wald*, and a subsequent one by *Dunhill* A feature in these cases, as in one of the writer's (Fig 144), is that the viscus is upside down The greater curve is uppermost and the cardia and pyloric region form the lowest points

FIG 144 —Complete thoracic stomach
The organ is upside down the greater curve being uppermost

The liver and spleen may be involved in a hernia, these are described in the section on the lungs

Radiological Features

TECHNIQUE —Many diaphragmatic herniæ are visible on *plain fluoroscopic inspection* of the diaphragm The erect position is the most satisfactory for this purpose Above the diaphragmatic line will be seen a projection, the hernial sac, in which, if it contains stomach or colon will be seen one or more air bubbles and possibly fluid levels below the gas If such a hernial protrusion is visible *in a postero anterior view*, *rotation* of the patient will show whether the herniation is at the lumbo costal angle *through the dome, or anterior* The

para œsophageal herniæ may easily be overlooked in a postero anterior view as they are then apt to be masked by the cardiac shadow If their presence is not suspected clinically, the only clue to their existence in such a view may be a faint gas bubble shadow with or without a fluid level

An opaque meal examination should be used in all cases of diaphragmatic hernia as a great deal of information is obtainable by such a method The examination should be continued until the splenic flexure is visualised in case that structure is herniated It may be necessary to employ a barium enema for this purpose

Radiographically the diaphragmatic herniæ fall into two groups those which herniate into the pleural cavity and encroach chiefly on the lung space and those—the para œsophageal group—which encroach largely on the posterior mediastinal space The demonstration of the first is fairly simple with a barium meal examination in the elucidation of the latter it may tax one's ingenuity considerably to obtain separate shadows of the stomach, œsophagus and other herniated structures

IN HERNIÆ OF THE STOMACH THROUGH THE DOME AND LUMBO COSTAL ANGLE the œsophagus is seen to be displaced at its lower end towards the hernia The stomach if herniated should be examined with the patient erect prone and supine In the erect posture the lower pole of the stomach shows a characteristic appearance As the fundus is raised the drag on the lower half of the stomach undoes the pyloric curve or hook to some extent so that the incisura tends to disappear the pyloric canal to point to the right and slightly downwards and the duodenal bulb to lie on a lower level than the pars pylorica This appearance is seen in any considerable herniation of the stomach of this type or the para œsophageal

In the prone or supine position—usually the latter—the upper half of the stomach fills and the precise position of the fundus filled with barium is easily determined The usual biloculation of the stomach caused by the hernial orifice is also visible In the region of the hernial orifice the gastric rugæ can be followed from upper to lower loculus A later stage in the examination will show whether any of the small intestine or colon is in the sac The presence of the spleen in the hernia is indicated if there is a considerable uniform opacity to be seen in the sac Rotation of the patient during screening and radiograms taken in two planes serve to determine the precise site of the herniation

In some cases if the hernia is small and not incarcerated it may be visible only with the patient lying down or in the Trendelenburg position

The chief problem in the differential diagnosis of this group is in distinguishing it from eventration of the diaphragm (*q v*)

THE PARA ŒSOPHAGEAL GROUP may not be seen on plain radioscopic inspection of the thorax but as they tend to give œsophageal and/or gastric symptoms they are commonly examined with a barium meal As the

opaque cream is traced down the œsophagus the gastric fundus can usually be made out above the diaphragm and close to the œsophageal shadow

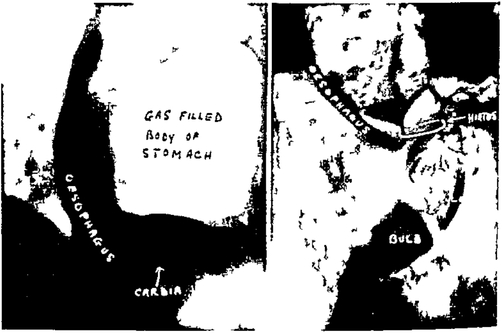
Having established the presence of a lesion belonging to this group, it becomes of first importance to determine whether it is a true herniation or a partial thoracic stomach The former is amenable to surgical treatment the latter is not They can best be differentiated by the use of the ' double swallow method in the Trendelenburg position as follows

The patient is first given enough of the opaque cream to fill the stomach reasonably full and then is placed in the Trendelenburg position on the X ray table By this procedure the herniated fundus filled with the contrast medium, is visible The patient is then given a large mouthful of the cream from a feeding cup and the progress of the barium watched under the screen *from the moment it is swallowed until* it reaches the cardia Still in the *Trendelenburg position the patient should be rotated right and left until a clear view of œsophagus cardia and gastric fundus is ob tained* When this view is obtained it can then be seen whether the œsophagus is of normal length or congenitally short One of normal length takes a looped course as it approaches the cardia indicating that a true herniation has occurred (Fig 145) If on the other hand the œsophagus runs straight down to the cardia the case is one of thoracic stomach (Fig 146) To ob tain a film showing this appearance with œsophagus cardia and fundus filled the time taken by an opaque *bolus to pass down to the cardia should be measured fluoroscopically Usually it takes two to three seconds* An exposure is then made the appropriate number of seconds after the patient swallows the bolus

Fig 145—Para œsophageal hernia of the stomach showing the angulation of the œsophagus.

In gross herniation of the stomach in which most of the viscus or all of it is in the thorax there is a tendency also to inversion (Fig 147) The greater curve swings upwards and forms the highest portion of the herniation The pylorus and cardia may be located fairly close together at the hernial

FIG 14[illegible] —Partial thoracic stomach with short oesophagus
1 Œsophagus 2 Cardia 3 Gastric fundus 4 Diaphragm



14[illegible] —Para oesophageal herniation of the stomach of the type shown diagrammatically in Fig 140 (f)

FIG 148 — *Congenital partial thoracic stomach with short œsophagus*

hiatus if the latter is small It is surgically of great importance in these cases to demonstrate the size of the hiatus, since those with a very wide opening may be difficult to repair The *hiatus is rendered visible* when the two "limbs" of the herniated viscus, afferent *and efferent, are filled*, and the technique of examination should be directed *inter alia* to this point

Dunhill points out that in many cases of partial congenital thoracic stomach with short œsophagus the cardia is at the top of an ill developed fundus (Fig 148) When examined erect, the narrowing of the barium shadow may simulate a carcinoma of the stomach In the Trendelenburg position the fundus *becomes distended with barium, and* the gastric rugæ at the diaphragmatic hiatus can be made out These two points, in addition to the short straight œsophagus, indicate the true nature of the c o n d i t i o n This authority also draws attention to a common and characteristic appear*ance in the œsophagus in true para* œsophageal herniation The œsophagus runs straight down to a point *just short of the herniated fundus, and* then makes an abrupt angulation, usually backwards and to the right, to sweep round the fundus in a loop (Fig 149)

FIG 149 — Para œsophageal hernia of the stomach, *the fundus passing into the right side* of the thorax This view (right anterior oblique) *shows the abrupt angulation of the* œsophagus where it reaches the gastric fundus

ACQUIRED AND TRAUMATIC HERNIÆ — Acquired non traumatic herniæ are commonest in the left

dome and traumatic herniæ occur at the side of the wound of the diaphragm. Radiographically they fall into one of the groups above described—usually the former. They should be radiologically examined in the manner already described.

EVENTRATION OF THE DIAPHRAGM

(*Syn.* Petit's eventration, Relaxatio or eventratio diaphragmatica, Unilateral congenital elevation of the diaphragm.)

In this condition the affected dome is in the form of a thin fibrous sheet, ballooned up into the thorax. In the vast majority of cases it occurs on the

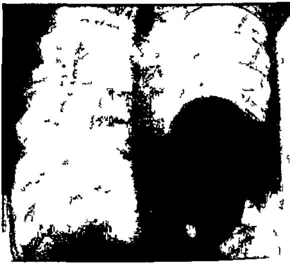


FIG. 150.—(*a*) Petit's eventration with marked displacement of heart and mediastinum to the right. The stomach was rotated with the greater curve uppermost.

(*b*) The same case supine. The gastric rotation has reduced itself.

left side. At the time of writing only nineteen cases of right-sided eventration have been recorded.

The abnormality was first described by *Petit* (1674–1750), a French surgeon. He recorded two cases, one of which appears to have been a true eventration and the other a diaphragmatic hernia. *Woodburn Morison* gave a full account of the condition in 1922.

ÆTIOLOGY.—This is still obscure. Paralysis of the phrenic nerve when developed gives an appearance exactly similar to the idiopathic or congenital eventration, and it is tempting to ascribe all cases of eventration to that cause. This could not account for the large preponderance of cases of eventration which

occur on the left side as phrenic nerve paralysis occurs on either side impartially Again in certain cases of congenital eventration which have gone to autopsy the phrenic nerve showed no abnormality

On the evidence available so far it appears probable that there are two types

(1) Congenital occurring on the left side almost exclusively

(2) *Secondary to phrenic nerve paralysis and occurring equally on either side*

The only features that help in distinguishing between them are the side on which the lesion occurs and any history of damage to the phrenic nerve

PATHOLOGY —The affected dome is composed of a thin fibrous sheet displaced *two to three interspaces upwards in the thorax Very commonly it is* situated on a level with the fourth interspace anteriorly As a rule there is no trace of muscular tissue in the fibrous dome

Radiological Features

Woodburn Morison grouped the radiological features under the following headings

(1) THE DIAPHRAGMATIC OUTLINE —This is high—several interspaces higher than the normal—and forms a regular bow line or arc right across *the hemithorax This arc is maintained by the ballooned gastric fundus* If the splenic flexure is gas distended also and in the dome there may be a slight notch in this arc at the point of apposition of the two structures Diaphragmatic hernia usually presents a different appearance The hernial sac produces a hump in the diaphragmatic outline and some portion of the diaphragm is usually visible If the hernia is very large resulting from almost complete absence of the left dome it may be impossible to distinguish it from an eventration Such hernial defects are as a rule incompatible with life

In right sided eventration the dome is not so high and shows no gas below it *In place of the dilated fundus tending to lift the dome there is the main* mass of the liver restraining the upward thrust of the abdominal musculature

(2) THE CONTENTS OF THE DOME —On the left the greatly distended gastric fundus occupies the greater part of the dome The splenic flexure also has its place therein *and at a lower level the spleen On the right side the dome is* occupied by the liver

(3) LUNG TISSUE VISIBLE THROUGH THE DOME —This will be seen if the gaseous distension is considerable and the lung tissue at the base of the lung posteriorly normally expanded

(4) MOVEMENTS OF THE DOME —These are of prime diagnostic importance and should be noted most carefully Movements are either absent or more commonly paradoxical i e an upward excursion takes place during inspiration and vice versa These paradoxical movements are never marked They are known on the Continent as Kienbock s sign and are said to occur occasionally in large herniae

(5) THE GASTRIC CONTENTS —A fluid level is commonly visible, unless the stomach is empty This level is stated always to be at that of the cardia This is explicable on consideration of the mechanism of eructation of gas This takes place usually when the individual is in the erect position *Gas will be expelled* from the stomach during eructation up to the point where the fluid gastric contents rise and seal off the cardia At that point escape of gas from the distended fundus into the gullet is stopped and consequently the fluid level is prevented from rising above the cardia

If the fluid level is of fair extent palpation of the abdomen causes ripples in it These are clearly seen on screen examination

(6) CARDIAC DISPLACEMENT —The heart usually shows some slight displacement to the right and also slight abnormal respiratory excursion moving to the right on inspiration

(7) GASTRIC DEFORMITY —This is present fairly constantly, and is of the nature of a biloculation According to *Morison* it is caused by an upward displacement of the greater curve into the dome, and a rotation of the stomach on its fixed points cardia and pylorus This torsion may amount almost to a volvulus and produces the bilocular appearance

Of the above signs the contour of the dome its position and its movements are constant and cardinal , the others are not always present

Differential Diagnosis —Temporary elevation may occur from marked gaseous distension of the stomach The elevation is not usually so marked and the diaphragmatic movements are normal In hernia through the dome the contour of the dome is less regular In one view at least, the postero anterior oblique or lateral the normal portion of the dome will be visible (with the exception of the rare cases of complete absence) The movements of the sac are variable There may be none or they may be reversed, or they may follow the movements of the remainder of the diaphragm The clue lies in the latter If any of it is visible fluoroscopically, its respiratory movements are seen to be normal

J Quenu has suggested two measures which might be of use in the differential diagnosis between eventration and a large hernia through the left dome (1) Pneumo peritoneum may enable the diaphragmatic and gastric fundal shadows to be seen dissociated This is hardly practical politics (2) Faradic stimulation of the phrenic nerve may produce visible movement of the remains of the diaphragm in a large hernia when none can be made out on ordinary forced respiration

PARALYSIS OF THE PHRENIC NERVE

This may result from many causes such as wounds in the neck, or pressure in the neck or the thorax—especially from mediastinal tumours It is commonly induced therapeutically in cases of bronchiectasis and pulmonary tuberculosis, and the sequence of events following phrenic avulsion is now

well known For a few days after section of the nerve slight normal movements take place in the paralysed dome Then over a period of two weeks the affected dome gradually ascends in the thorax and either becomes immobile on respiration or presents reversed movements usually slight in range During this period atrophy of the muscle takes place On the left side thinning and stretching of the degenerated muscle continue until in some cases the typical picture of left sided eventration is reached

SUBPHRENIC ABSCESS

Subphrenic abscess arising as a complication of perforated peptic ulcer gall bladder disease or appendicitis may occur on either side On the right side the abscess forms between the liver below and the diaphragm above On the left side the lower boundary is formed by stomach and spleen

X-ray Features—In a typical case the dome is rather high—a centimetre or two raised—and may be fixed on respiration The diaphragm is rendered immobile by a protective reflex similar to that which places the abdominal musculature on guard in peritonitis Any deformity of the contour is unusual In a percentage of cases gas is present in the abscess cavity (Fig 151) This arises either from the passage of air from the stomach through a perforation or from the direct action of gas forming organisms such as *B welchii*

Fig 151—*Subphrenic abscess with formation of gas under the right dome*

On the right side of the abdomen this gas is obvious if the patient be examined erect and although these patients are as a rule very ill a radiogram can usually be obtained with the patient sitting up in bed In such a posture the gas is clearly seen in a layer between diaphragm and liver if the amount of gas present be considerable a fluid level in the abscess cavity will be apparent Two other conditions can give a somewhat similar appearance of gas in this region On rare occasions a loop of transverse colon wanders up between the liver and diaphragm and may contain gas Again in a para œsophageal

hernia the herniated gastric fundus may lie to the right of the œsophag[us]. The clinical features are enough to exclude these two

On the left side the dome is raised and immobile but if gas be present it m[ay] be difficult or impossible to differentiate it from gas in the stomach or colon

Changes in the base of the lung overlying the abscess are commonly foun[d]. A small pleural effusion enough to fill up the costo phrenic angle is frequent[ly] present In the lung itself a varying degree of striated opacity disposed in [a] horizontal layer across the base and a little above the diaphragm is a usu[al] appearance in these cases This represents a congestive reaction with som[e] degree of collapse from the upward displaced diaphragm If the opacity [in] the base of the lung be considerable it may be difficult to decide wheth[er] a pneumonic consolidation and not a subphrenic abscess is the cause [of] the trouble

SUBHEPATIC ABSCESS PERIRENAL ABSCESS

In this condition the dome is raised a little and fixed no pulmona[ry] *changes are present as a rule It is described in the section on t[he]* urinary system

TUMOURS AND ENLARGEMENTS OF THE LIVER

The exact amount of elevation of the dome and the degree of distortio[n] thereof will depend on the nature of the hepatic enlargement Hydatid cys[ts] and tumours if situated near the upper surface of the liver may produce [a] mild rounded bulge in the diaphragmatic contour but usually no suc[h] deformity is produced

Hepatic enlargements from general diseases such as cirrhosis or congestio[n] produce no distortion of the outline In examining these hepatic abnormaliti[es] radiographically it is important to take note of the position of the lower edg[e] which is usually visible in a plain radiogram of the upper abdomen

GROSS ENLARGEMENT OF THE SPLEEN

This may raise the left dome to some extent The clinical evidence is decisiv[e]

FREE GAS IN THE PERITONEAL CAVITY

As this is usually demonstrated radiographically in relation to the diaphragm it may be considered here It may result from

A Laparotomy —This is the commonest cause and on being presente[d] with a radiogram showing gas in the peritoneal cavity this point should fir[st] be determined Air is slowly absorbed and traces may be found in a[n] abdomen a week after operation

B Perforations of the Alimentary Canal

C Gas forming Abscesses e g subphrenic

D ACCIDENTAL PERFORATIONS of the abdominal cavity during artificial pneumothorax, etc

E AIR INSUFFLATION OF THE FALLOPIAN TUBES, if successful

Radiological Demonstration.—*The best site to demonstrate free air is under* the right dome of the diaphragm This normally contains no gut; the liver keeps the latter well removed The examination, screening and radiographic, should be in the erect or sitting posture, usually the latter is all that is possible, but it suffices If only the recumbent posture is permissible, the patient should be placed on his left side, the tube centred horizontally in front of him, and the film behind The radiogram will show air between the lateral abdominal wall and the liver If, in the sitting position, a crescent of gas is seen between the liver and diaphragm, it is almost certainly due to free air One fallacy already mentioned must be taken into account, that of hepato dia phragmatic interposition of the colon On the left side the gas bubbles in the stomach and splenic flexure complicate the appearance, but if much free gas be present, it can be recognised also on this side

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PART ONE

SECTION III

SMALL INTESTINE, APPENDIX AND LARGE INTESTINE

CHAPTER XV

THE SMALL INTESTINE TECHNIQUE, ANATOMY, AND PHYSIOLOGY

For the purpose of this section the small intestine may be regarded as that portion of the alimentary canal between the duodeno jejunal flexure and the *ileo-cæcal junction*.

TECHNIQUE OF INVESTIGATION

The small intestine is investigated by the opaque meal. Although the barium enema occasionally leaks past the ileo cæcal sphincter into the terminal ileum this is an undesirable accident in that examination rather than a practical means of investigating the ileum. While the barium meal forms the principal method of investigation, at times some information may be gained by a plain radiogram particularly in small intestine obstruction. Air then forms the contrast medium.

Fluoroscopy and radiography are both of importance in the investigation of the small intestine. *Fluoroscopy is of value in the study of its function.* By it peristalsis can be observed, and also the passage of the opaque meal along the jejunum and ileum. This is best conducted in the supine position. For the demonstration of fluid levels, the erect posture is necessary.

Radiography gives the opportunity to study the morphology of the gut in detail and *a series of radiograms taken at fifteen minutes thirty minutes, one* hour, three hours and six hours after the ingestion of an opaque cream will as a rule show the various portions seriatim.

ANATOMY OF THE SMALL INTESTINE

The small intestine is arbitrarily divided into an upper portion, the *jejunum* about *8 feet in length, and a lower the ileum* about *12 feet in length*. The jejunum occupies the upper left part of the abdomen, below the transverse colon and stomach. The ileum lies in the lower right region. Very frequently the lower part of the ileum lies in the pelvis the terminal portion being directed upwards to join the cæcum.

There is no abrupt change from jejunum to ileum The transition is a very gradual one Nevertheless, if a portion of the upper jejunum be contrasted with the lower ileum, marked differences are evident anatomically (and consequently radiographically) *The jejunum is larger in calibre, and its* mucous membrane bears many plicæ circulares closely approximated to each other The Peyer's patches are few small and far between The ileum is narrower *has many Peyer's patches and gradually loses its plicæ altogether* as the lower end is reached

The mesentery renders the jejunum and ileum freely mobile, but in spite of this they tend to keep their relative positions in the abdomen fairly constantly

MOVEMENTS OF THE SMALL INTESTINE

The classic experiments of *Cannon* on anæsthetised animals with the peritoneal cavity opened and the gut exposed and radiographically in the intact animal showed three types of movement rhythmic segmentation, true *peristaltic waves and pendulum movements*

The segmentation is supposed to occur first, after the gut has been filled A series of annular contractions occurs dividing the contents into discrete masses In seven to ten seconds a second series appears, splitting these boluses the halves joining with their neighbours The function of this is supposed to be thorough admixture of the food with the intestinal juices When this has proceeded for upwards of half an hour peristalsis is then said to occur driving the food slowly down the small intestine, at the rate of an inch or two per minute

Radiological Features —Radioscopic investigation in the human subject after a barium meal shows a very different picture The movements are seen *to vary to a great extent in the jejunum and ileum*

THE JEJUNUM shows a state of restless activity Pendulum movements are never seen As soon as the first bolus of the opaque cream passes round *the duodenum and over the duodeno jejunal flexure it is swept rapidly through* the first few coils of the jejunum and at the same time assumes a finely fragmented state As succeeding portions of the meal are delivered by the *duodenum those that have gone before are driven by peristaltic waves farther* down the jejunum until most of that portion of the intestine is flooded with barium cream in a fine state of subdivision (Fig 152) The onward progress of *the meal is the result of peristalsis but of a much more rapid and vigorous* nature than was described by the experimental workers

The fine fragmentation of the contrast medium is at first sight perhaps puzzling but becomes clear on a consideration of living anatomy *of the jejunum* If a large bolus be observed entering the jejunum, the gut is momentarily distended and a homogeneous shadow appears sharply indented by the plicæ circulares This distension however at once stimulates a *peristaltic wave* and on the passage of this wave the gut resumes its normal degree of patency,

namely a state sufficiently collapsed to throw the plicæ and mucosa into a fine rugosity the interstices of which are filled with a thinly spread layer of intestinal contents The muscularis mucosæ plays an active part in this "plastering of the mucosa and the radiographic effect is to produce a uniform mucosal relief pattern The physiological object of this is obvious—to obtain intimate mixture of the food and intestinal secretions and the subsequent absorption of the food when digested The rapid peristaltic transit of the meal down the jejunum likewise aids both processes by bringing into use as large a surface of jejunal mucosa as possible

Fig. 10[illegible].—Prone view of the normal duodenum jejunum and ileum two hours after an opaque meal

In individuals in whom gastric evacuation is very rapid the jejunum has to accommodate such a large quantity of the contrast medium that fragmentation is unable to take place at first and a considerable length of the jejunum may show a more or less homogeneous shadow but this overloading is probably much rarer in ordinary circumstances since a plain barium cream passes out of the stomach much more quickly than ordinary food After gastro jejunostomy and partial gastrectomy it normally occurs to a marked degree

THE ILEUM.—As the opaque medium reaches the ileum a gradual change in the X ray appearance takes place The peristaltic activity is slowed down, and the rate of transit diminished As the rugosity of this portion of the

small intestine is much less and the plicæ progressively fewer in number fragmentation of the ileal contents does not take place It is here however that segmentation activity can be made out to some degree and this is the more clearly seen the nearer the ileo-cæcal junction is approached These two movements—peristalsis and segmentation—are difficult to make out fluoroscopically because of the close apposition of the ileal coils The terminal ileum often lying separate from the remainder of the ileal coils is the least active part of the small intestine It is typically a more or less straight segment running upwards and outwards from the pelvis to the ileo cæcal junction By careful observation under the screen slow segmentation can be made out in this portion and at infrequent intervals a peristaltic wave ejecting a bolus of chyme into the cæcum

Morphologically the TERMINAL ILEUM shows many minor variations in disposition and contour Care should therefore be exercised in pronouncing any given appearance as pathological Its mobility in itself and its mobility relatively to the cæcum and appendix should be carefully noted Its absolute mobility depends on the length of its mesentery and usually decreases in degree as the ileo-cæcal junction is approached It should be borne in mind that the mesentery may virtually disappear in the last few inches of the ileum in which case that portion will be relatively immobile The terminal ileum should also be mobile relatively to the cæcum and appendix Fixation to either of those shadows is worthy of suspicion

The terminal ileum is best investigated at the sixth or seventh hour after the ingestion of a barium meal and is most accessible to palpation with the patient supine Occasionally even in that posture it and the cæcum are so deeply situated in the pelvis as to be beyond the effective reach of the manipulating hand In such case the cæcum may occasionally be coaxed from the pelvis by the Trendelenburg or knee-elbow position

RATE OF TRANSIT THROUGH THE SMALL INTESTINE

This is so variable that no exact figures can be laid down Fortunately it is of little importance except for the question of ileal stasis

The average time for the head of a barium meal to reach the ileo-cæcal junction is one and a half to two hours According to *Hurst* the small intestine should be clear four hours after the completion of gastric evacuation This time is often exceeded and it is not uncommon to find the last few inches of the ileum filled with barium seven hours after a meal and more than four hours after the stomach is empty The amount of the gastric residue should be taken into account as well as the time factor in the assessment of ileal stasis

THE GASTRO ILEAL REFLEX —When food enters the stomach the terminal coils tend to empty into the cæcum This was described by *Hurst* under the term gastro ileal reflex It is an index of the close association between

these two portions of the alimentary canal, and is said to be inhibited in chronic appendicitis It has its pathological counterpart in the "ileo gastric" reflex of *Barclay* In this connection *Barclay* noted gastric stasis in cases of disease in the region of the terminal ileum The inference is that a lesion in the right iliac fossa, such as a chronic appendicitis, if it be causing ileal stasis, produces a reflex closure of the pylorus as soon as the ileum becomes filled with food, and thus slows down the rate of gastric evacuation in its later stages

THE ILEO-CÆCAL VALVE

This valve is really a sphincter, according to *Keith* It is responsive to peristalsis of the terminal ileum, when it opens, and is said reflexly to close—or exhibit achalasia—in response to the stimulus of a chronic appendicular lesion Its competency as a valve to the pressure of a barium enema is very variable *in at least 50 per cent of cases it is incompetent, and the opaque enema passes* freely into the ileum

It has been suggested that this incompetence is pathological, although in what exact way it is not quite clear Indeed, one surgeon devised an operation to fashion a new valve to prevent regurgitation an interesting example of surgical carpentering gone mad, to the exclusion of all physio logical considerations

In the writer s opinion competency or otherwise of the ileo cæcal valve is of *no clinical or diagnostic significance* whatever

CHAPTER XVI

DISEASES OF THE SMALL INTESTINE

MECKEL S DIVERTICULUM

THIS is an important structure surgically It is a congenital abnormality resulting from the persistence of the intra abdominal part of the vitelline duct It usually springs from the convex or anti mesenteric border of the ileum somewhere within 2 feet of the ileo cæcal junction It occurs in 2 per cent of subjects

Varieties —The normal process of obliteration of the vitelline duct may be arrested at any stage The diverticulum may be a blind-ended patent tube a fibrosed cord connecting ileum to umbilicus a combination of these two or it may form a fistulous opening at the umbilicus The complications which may arise from this abnormality are several including acute diverticulitis intussusception volvulus or strangulation of small intestine by the diverticulum acting as a band Patients are frequently sent to the X ray department for investigation of a possible Meckel s diverticulum but it is frequently impossible to demonstrate the condition radiographically A positive diagnosis of Meckel s diverticulum can be made only when the diverticulum is seen *filled* with barium and so disposed as to demonstrate both the blind end and the connection with the ileum

Apart from this radiology can afford help in two complications—chronic obstruction resulting from band like action and fistulous communication of the umbilicus In the former the approximate site of the obstruction can be demonstrated but not the cause and in the latter injection of the fistula with a barium cream will show its connections clearly

ACQUIRED DIVERTICULA

Acquired diverticula of the small intestine are not uncommon They consist of protrusions of the mucosa through the muscularis at the mesenteric border are usually multiple and tend to develop particularly in the ileum They vary in size from a pea to a hen s egg

These diverticula have little clinical significance They rarely become inflamed or give rise to symptoms The chief radiological importance they have is in differential diagnosis for in the erect positions they may give rise to fluid levels in a radiogram

The radiographic features vary according to posture If the patient be recumbent the diverticula appear after a barium meal has reached the small in

testine as rounded shadows (Fig 153) In fortunate circumstances the narrow communicating neck may be seen and the nature of the condition clearly established

As some gas tends to collect in these diverticula in the erect posture fluid levels are often visible between gas and fluid contents or gas and barium if a barium meal has been given and it is only in connection with these fluid levels and their interpretation that jejunal and ileal diverticula have any importance

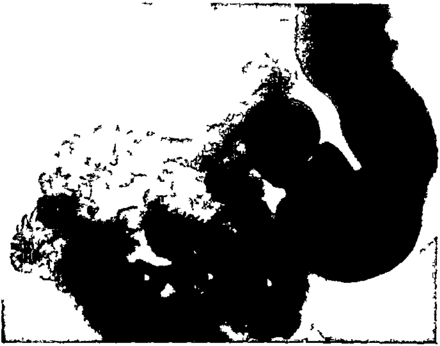


Fig 153 — Multiple jejunal diverticula (D)

radiologically The presence of fluid levels is an important radiographic feature of small intestine obstructions and must be distinguished from those of diverticula The differentiating feature of the diverticular type is the globular nature of the combined air and fluid shadow and its small size The main portion of the bowel is seen to be normal in calibre and mucosal pattern and the demonstration of the diverticular necks is decisive

FISTULÆ IN CONNECTION WITH THE JEJUNUM AND ILEUM

The radiographic demonstration of external fistulæ of the small intestine is as a rule simple

All that it is necessary to do is to mark the opening of the fistula with a wire ring inject a little barium cream through the fistula and

bution in the abdomen under the fluorescent screen Stereoscopic radiograms are sometimes of value in showing the ramifications of the sinus and its connection with the bowel (Fig 154)

Internal fistulæ are more difficult of elucidation unless the communication be with a viscus other than the small intestine e g stomach colon or gall

Fig 154—Double external and single internal fistula of the small intestine following appendicitis On injecting an opaque cream into the lower sinus (1) the cream outlined the small intestine escaped from the upper sinus ( ) and finally tracked along towards the caecum

bladder If the fistula be between high jejunum and low ileum a barium meal might give a clue by showing the short-circuiting of a large portion of the intestine but a negative result would obviously be of little significance in this connection

OBSTRUCTION OF THE SMALL INTESTINE

Acute Obstruction of the small intestine is a surgical emergency and as such rarely reaches an X ray department Of recent years however mobile

ward X ray apparatus has made it possible to X ray such cases quickly and without disturbing them, and information may be obtained, by a plain radiogram taken in this way, as to the site of the obstruction Needless to say, no contrast medium may be given, but the gas present in the gut above the obstruction is often sufficient for this purpose In obstruction of the small intestine the gas filled dilated coils above the block are visible, while the colon is collapsed Some idea of whether the block is high or low in the gut may be obtained by the number of distended coils

Patey and *Ascroft* have drawn attention to the different pattern made by the various sections of the intestine in a state of acute distension This may be a help in determining the site of an obstruction since they may be visible in a plain radiogram Fig 155 shows the appearance in isolated coils The first 10 feet of the jejunum shows a regular and complete cross hatching, from the shadow of the stretched plicæ The ileum shows no sign of plicæ The colon presents an outline retaining some trace of haustration while the plicæ are incomplete and tend to interdigitate

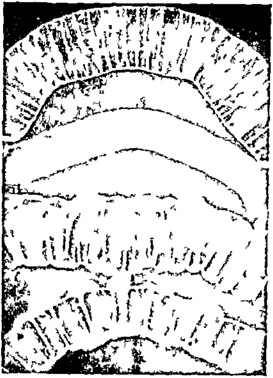


FIG 155 —Plain radiogram of isolated coils of intestine distended with air to show typical distension pattern of different segments of intestine jejunum ileum transverse colon pelvic colon from above downwards

In acute obstruction the erect posture is rarely possible Occasionally the patient may be raised on a tilting table, but to demonstrate a fluid level satisfactorily the perpendicular must be attained and a more practical method of demonstrating these levels is with the patient horizontal and in the right or left lateral position The radiation is horizontally directed, and postero anteriorly relative to the patient, with the film in front

Chronic Obstruction —It is however, in chronic obstruction of the small intestine that most information can be obtained for in it a barium meal may be given and the state of affairs more clearly made out

A note of warning must be sounded regarding the use of the barium meal in these cases Only if it is quite certain that the obstruction is chronic and

not acute dare one give a barium meal. Further, if the chronic obstruction turns out to be colonic, disaster may result. In such case, inspissation of the slowly moving column of barium may convert a chronic obstruction into an acute one. It is therefore safer first to make a barium enema examination to exclude colonic obstruction. Having done so the meal may then be given to investigate the state of the jejunum and ileum.

RADIOGRAPHIC APPEARANCES.—In the *erect position* horizontal fluid levels form the most striking feature of small intestine obstructions (Fig. 156). In plain radiograms this fluid level is rendered visible by the collection of gas above it. If a barium meal has been given, the barium filled coils are also seen. The length of these gas fluid levels is variable and the large size of some of them serves to distinguish them from the shadows seen in diverticula. Occasionally gas and liquid fæces in the ascending and transverse portions of the colon may present fluid levels but these are usually limited by haustral contraction and their colonic distribution is usually clearly apparent.

FIG. 156.—Obstruction of terminal ileum from adhesions. Plain radiogram in erect position showing multiple fluid levels.

In the supine or prone position the dilated barium filled coils give a characteristic appearance (Figs. 157–160). A ladder pattern may be assumed by the coils and the mucosal relief pattern of the coils themselves is very typical. The lumen is widened and the barium coated plicæ cause a close cross hatching in the mucosal relief pattern. The plicæ, being stretched with the dilatation, lose their normal sinuous reduplications. This straightening of the plicæ is the deciding point in the estimation of obstructive jejunal distension.

A rough guide as to the site of the obstruction is given by the number of distended coils and the extent to which they fill the abdominal cavity. If the obstruction be colonic the small intestine obstruction is as a rule less and gaseous distension of the colon fills the picture literally and metaphorically.

The degree of peristaltic activity as seen on screen examination varies according to the degree and duration of a chronic obstruction. If marked

atony is present, peristalsis is not evident, but as a rule some degree of hyperperistalsis can be seen

In some of these cases a hypogastric splash can be elicited on clinical examination Under fluoroscopic palpation in the supine position the actual

FIG 157 —Duodeno jejunal ileus from obstructing band (Prone view)

coils in which the splash occurs can be determined This, when obtained, is *an important sign, and one practically pathognomonic of chronic obstruction*

HERNIÆ OF THE SMALL INTESTINE

The presence of a loop of the small intestine in a hernial sac can as a rule be demonstrated by a barium meal examination This is best seen in the inguinal variety when the barium filled loop *is observed descending into the scrotum* In the femoral type it is seen in the upper inner part of the thigh, and in the ventral hernia a lateral view shows the barium filled gut in the sac It is inadvisable to employ this method for the demonstration of incarceration for fear of overloading the loop with barium and so precipitating a strangulation In cases of strangulation it is obviously not only inapplicable but actually dangerous

TUMOURS OF THE SMALL INTESTINE

The small intestine is rarely the site of neoplasms, either benign or malignant

OF THE INNOCENT TUMOURS the least uncommon are the adenomas either

FIG 1 8 Ileal obstruction with jejunal dilatation Prone view showing typical cross-hatching

solitary or multiple Still rarer are fibroma lipoma and myoma All types tend to become pedunculated

Whilst in theory they should when they obtain a moderate size be demonstrable in a barium meal examination in practice they give no clinical hint of their existence until they cause intussusception or obstruction when the radiographic picture is that of the complication

CARCINOMA of the small intestine is usually situated in the lower ileum and tends to form an annular constriction leading to obstruction *Hohe*

has reported a case of non obstructing carcinoma of the jejunum which showed, with the barium meal, a solid filling of the affected segment, with absence of *any mucosal pattern therein, and without any dilatation proximal to the lesion*

SARCOMA usually occurs in early life and shows less tendency to stenosis of

FIG. 109.—Chronic obstruction in the small intestine from a carcinoma of the cæcum. The ileum is grossly dilated and on clinical examination a marked hypogastric splash could be elicited

the bowel than does carcinoma. It sometimes becomes pedunculated in the early stage

CHRONIC ILEITIS

Tuberculous Ileitis occurs in two forms, ulcerative and hypertrophic

The ulcerative type is usually secondary to an active tuberculosis focus elsewhere, e g the lungs. The disease begins as an ulceration of the Peyer's patches in the lower ileum. The ulcers tend to spread in an annular direction, and subsequent cicatrisation produces multiple stenoses of the gut. It is in this latter stage that it gives radiographic evidence of its nature

filled lumen is seen to be irregularly contracted, the contracted areas remaining constant on repeated examinations As the obstruction becomes more marked, the bowel above develops the picture of chronic intestinal obstruction already described Since the radiographic appearances are not exclusive to this condition the diagnosis ultimately rests on the evidence of active tuberculosis elsewhere, the demonstration of tubercle bacilli in the fæces, or the appearances at operation

The hypertrophic form is described under ileo cæcal tuberculosis in the section on the colon

Plastic Ileitis (*syn* **Regional ileitis, Crohn's disease**) —*Crohn, Ginzburg,*

Fig. 160 Ileal stasis seen 7 hours after a barium meal cause unknown

and *Oppenheimer* gave a full account of this condition in 1932, a stenosing and plastic ileitis of the last foot of the ileum

The cause of the condition which usually affects young adults, is unknown

Clinical Features —The terminal ileum alone is involved The disease begins as a subacute or chronic ulcerative ileitis, and proceeds to stenosis Fistulæ may develop opening into the cæcum or colon The process involves the ileo cæcal junction, but not in the first place the cæcum, and is most marked at the juxta cæcal portion The course is relatively benign and simulates clinically an ulcerative colitis, with diarrhœa, and blood and mucus in the stools Some fever may be present, and a tender mass may be felt in the right iliac fossa

Radiographic Features.—In the pre-fistulous stage the barium enema reveals no abnormality, but an opaque meal shows a varying amount of ileal stasis and dilatation above the lesion, depending on the degree of stenosis. The involved segment itself presents an irregular narrowing of its lumen, most marked at the terminal end, and an absence of peristaltic waves (Fig. 161).

When fistulæ have formed, deformity in the colon may be seen from the spread of the stenosing inflammation to the colonic wall. This may cause a

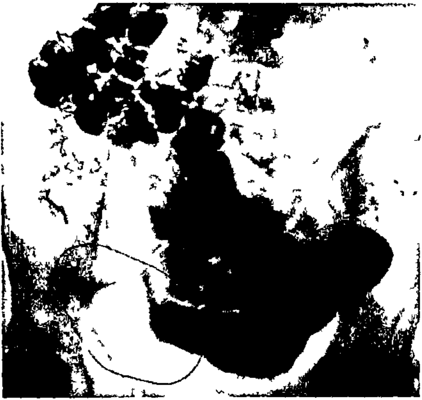


Fig. 161.—Crohn's disease with involvement of caecum and fistula between ileum and proximal transverse colon. Six-hour meal picture showing narrowed ileum and Stierlin's sign in caecum. The wire marks the t[illegible] of the colon wall.

filling defect in the ascending colon or sigmoid closely resembling a carcinoma, the fistula being accounted a cancerous one. *J. L. Kantor*, in a report on 6 cases, noted the presence of spasm of the cæcum (Stierlin's sign). In a case seen by the writer (Fig. 162) this contracture of the cæcum was partly spastic and partly organic. The barium meal showed marked narrowing due to both factors, and a subsequent barium enema the lesser degree of organic contracture, the spasm having relaxed. Kantor also noted a string sign in the affected portion of the ileum, and points out that this may be double

when a fistula has developed due to barium in the contracted ileum and in the fistulous track

DIFFERENTIAL DIAGNOSIS — X ray diagnosis of this condition may be difficult owing to its resemblance to tuberculosis and actinomycosis of the ileo-

(a) ( )

FIG 162 Crohn's disease same case as Fig 161 after a barium enema (a) shows the initial caecal spasm (Stierlin's sign) and ( ) the residual contracture 15 minutes later after the spasm had relaxed (This case proved histologically and bacteriologically)

caecal region When perforation into the colon has occurred it is apt to be mistaken for cancer of the latter viscus Ulcerative colitis Hodgkin's disease lymphosarcoma and chronic hyperplastic appendicitis are mentioned as other conditions which may simulate it and the true nature may be apparent only on the operating table or on histological examination

CHAPTER XVII

THE APPENDIX

RADIOLOGY PLAYS no part in the diagnosis of acute appendicitis

For years controversy has continued over the radiological diagnosis of chronic appendicitis and no finality has yet been reached

It has followed its clinical counterpart in fashion and out and has in the past too often provided the *pis aller* of the diagnostically destitute It might almost be said that Mr Punch s advice applies here also! While this is an intentional hyperbole its object is to stress the caution which must be exercised *in making such a diagnosis on radiological grounds alone In a certain per*centage of cases the X ray evidence is sufficiently strong to enable this to be done but more frequently the signs are less frank When in doubt tend to give the appendix the benefit of it

TECHNIQUE

The appendix may be demonstrated by the barium meal and by the barium enema The former is the more generally useful for several reasons Firstly *by the meal the presence of an organic gastric or duodenal lesion is confirmed* or excluded secondly the presence of ileal stasis from obstructive adhesions may be shown, again the cæcum is not usually so distended by a meal as it is by an enema and less chance occurs of the appendix being masked Appendicular and cæcal stasis are more satisfactorily studied by a meal The enema if the ileo cæcal sphincter is patulous may flood the ileum and render it impossible to see the appendix In certain cases where it is desired to test whether an irregularity of the appendicular lumen shown by the opaque *meal is constant or whether failure to fill it is due to obliteration of the lumen* a barium enema may be of help

The thorium double contrast enema has the advantage that if successful the cæcum is relatively empty and does not obscure the appendix It is however not always possible to fill the appendix with this method nor to empty the cæcum for the collapsed stage It is particularly useful in cases of retro cæcal adherent appendices in which it is impossible to obtain a profile view

For the barium enema the writer uses no special variation from the standard *opaque cream Various special media have been advocated such as* arrowroot and buttermilk it being claimed that they ensure filling of the appendix in a larger percentage of cases It is very doubtful whether they have the slightest effect in this respect or that they are worth the trouble of preparation

According to *Kerley* the *Cambies* technique is successful in visualising the normal appendix in nearly 100 per cent of cases This consists in giving by mouth three hours after the meal a concentrated saline solution such as Mag Sulph 1–2 drachms in 3 oz of water

Gottheiner's technique consists in giving castor oil twenty four to forty eight hours after taking the barium meal Filling of the appendix is said to occur in a large percentage of cases a few hours after this procedure In *Maingot's* hands this was a less successful special technique than *Cambies*

For the examination of the appendix the meal should be taken in the morning and the stomach and duodenum first investigated The patient should subsequently be seen at seven twenty four and thirty hours after taking the meal and on subsequent days as necessary

The seventh hour is of importance in the detection of ileal obstruction and to show the relationship between the appendix and ileum Sometimes the normal appendix is not filled at the seventh hour but it can usually be seen at the twenty fourth or thirtieth Examination on subsequent days is necessary only to determine the presence of appendicular stasis

Careful fluoroscopic palpation of the appendicular region is an essential procedure at each stage The patient should be supine and the abdomen well relaxed

The following points require attention during this fluoroscopic examination the position and size of the appendix its mobility the contour of its lumen with particular reference to kinks and stenoses and the presence of tenderness on pressure over its shadow

In addition to fluoroscopy radiograms should be taken at each stage Pressure may be necessary to separate the appendicular from the cæcal and or ileal shadows For this purpose the best instrument is the patient's left hand The exact position and degree of pressure is easily determined fluoroscopically The patient is instructed to relax the hand and re apply the pressure several times to make certain that the same separation effect is achieved each time Then the patient's hand still remaining in the same position the film is placed in position the pressure reapplied by the patient and the exposure made The shadow of the patient's hand is nearly always to the left of the cæcal and appendicular shadows and does not obscure them

FILLING AND EMPTYING OF THE APPENDIX

There is doubt as to the precise mechanism of filling The prevailing view is that filling of the appendix is a passive phenomenon except for relaxation of the sphincter It occurs with most certainty at the time of maximum filling of the cæcum and may be present at any time between two and twenty four hours after ingestion of the meal If it has not filled in that time it is unlikely that later stages of the examination will find it visible

The emptying of the appendix is an active peristaltic function. It is sometimes possible to observe the phenomenon of emptying during screen examination—usually in the form of a change in the appearance before firm radioscopic palpation compared with after. In this case the emptying may be the result of direct pressure. Apart from palpation it is not possible to make out any change fluoroscopically. Serial radiograms do however reveal changes in contour indicative of peristaltic activity. A not uncommon appearance is segmentation producing a rosary effect. The importance of

Fig. 163.—Normal appendix.

Fig. 164.—Normal appendix showing a peristaltic wave.

differentiating muscular from cicatricial constrictions is obvious and indicates the necessity for re-examination at successive intervals.

NORMAL APPEARANCES

The classical appearance of the appendix in a barium meal is that of a *blind tube 3 to 4 inches in length, 2 to 4 mm. in calibre, and showing a gentle* single or double curve (Figs. 163-165). From this prototype there may be marked variation in many respects. Its length may vary from ½ inch to 9 inches. Its lumen may be represented by a mere thread of barium or be 5 to 6 mm. in width. Quite acute angulations may be simulated in a foreshortened view. The lumen, classically uniform in calibre, may be slightly narrower towards the base. A more important variation in this respect is that due to muscular contraction. Such narrowings are inconstant.

The appendix should normally be freely mobile on palpation, but if the cæcum be pelvic in site it may be inaccessible to such manipulation. The

position of the appendix is normally very variable. It is most commonly found lying to the inner side of the cæcum, but may lie behind the cæcum to the outer side of it, turn upwards to the liver, or hang down into the pelvis. The appendicular mesentery may be very short, in which case the mobility of the appendix is restricted.

Fig. 1[illegible].—Normal appendix with fæcal contents near the tip. The organ was visible only on displacement of the terminal ileum by the observer's gloved hand.

CHRONIC APPENDICITIS

Pathology

For a proper assessment of the value of the various abnormal X-ray signs observed in and round the appendix, it is important to have some appreciation of the pathological conditions which may be present.

(1) The mucosa may be in a chronic catarrhal state. If it is œdematous the lumen will be narrowed.

(2) Repeated attacks of appendicular catarrh tend to cause fibrosis of the submucous and muscular coats. This causes local or general stenosis of the lumen and lessens the peristaltic activity of the organ.

(3) Stasis of the appendicular contents from such stenosis often results in the formation of fæcal concretions. These in turn tend to promote further catarrhal attacks.

(4) The peritoneal coat may become inflamed and as a result the appendix become adherent to adjacent structures. It may be adherent in its middle, causing a fixed angulation, or by its tip. A typical adhesion is that of the appendicular tip to the adnexa. In the "controlling appendix" of *Lane* the appendix is adherent to the terminal ileum and acting like a band causes stasis in the ileum proximal to it. It is doubtful if a chronic appendicular lesion causes ileal stasis apart from such mechanical factors.

Radiological Signs of Chronic Appendicular Disease

No one sign is pathognomonic. Almost every one of them is susceptible to two interpretations—as a normal variation or as a pathological condition.

The probability of an organic change being present increases in direct ratio to the number of these individually dubious signs detected The probability is further increased if a subsequent examination shows an unchanged radiological picture In other words constancy in an abnormal feature is an important indication that it represents a pathological change

Many signs have been described Among the more inherently reasonable of these are the following

(1) NON FILLING OF THE APPENDIX —This may be due to fibrotic stenosis *of the lumen The fallacy is that a certain small percentage of normal* appendices do not fill and that the healthy appendix fills and empties itself at intervals

(2) INCOMPLETE FILLING —Where only part of the appendicular lumen is filled it is necessary to determine if possible whether this is due to stenosis of part of the lumen or an empty phase in the appendicular cycle of activity Again *part of its lumen may already* contain transparent contents

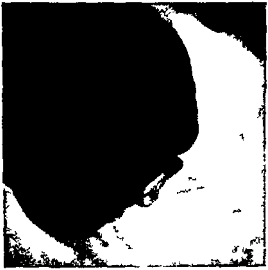


FIG 166 —Chronic appendicitis The appendix contained a terminal concretion showed an Indian club deformity and was adherent to the cæcum

(3) APPENDICULAR CONCRETIONS —Some of these contain phosphorus and calcium and so cast a shadow the majority are transparent The former are visible in a plain radiogram and are liable to be mistaken *for any of the following* ureteric stone renal stone gall stone phlebolith The only positive proof of their nature is their demonstration in a barium-outlined appendicular shadow They cast a lighter shadow than the barium and therefore show in semi relief Shot from game and barium from a previous meal are easily recognisable The transparent concretions are *composed of inspissated fæces and can be seen only when the appendix is* filled with the opaque medium when they show as an oval gap in the appendix shadow (Fig 166)

(4) IRREGULARITY OF THE APPENDICULAR LUMEN —To be of organic import an irregularity of the barium filled lumen must be constant in a series of radiograms This can be tested at one seance by firm radioscopic massage of the appendix between the taking of two radiograms Variations due to *muscular tonus and peristalsis vary , those due to fibrosis do not* Even if this test produces no change it is as well to check it on a subsequent day or by means of the barium enema (Fig 167)

(5) Fixation of the Appendix —This usually indicates the presence of adhesions and should be tested fairly vigorously as it sometimes requires considerable pressure to dislodge a mobile appendix This applies particularly to one whose tip lies in the pelvis Rarely the fixation is due to a short meso appendix

Fig 16 Appendix adherent at its tip at an 1 24 hours after the meal At both examinations the tip was immobile on radioscopic palpation

(6) Fixation of the Cæcum and/or Ileum —*This results from* peritoneal adhesions except in the rare cases of anatomical fixation Two types are worthy of mention In the so called controlling appendix described by *Lane* the appendix is adherent across the terminal ileum and not only binds it down to the posterior abdominal wall but causes obstructive ileal stasis Although *Lane* regards it as a common occurrence in the writer s experience it is rare (Fig 169)

A commoner type of adhesion is that of the last few inches of the ileum to the inner border of the cæcum The appendix usually lies somewhere in the angle between these two structures and appendicular inflammation is therefore prone to excite adhesive peritoneal reaction on the two adjacent viscera The resulting adherence is visible radiographically by the close apposition of the barium filled cæcum and ileum even on firm palpation The appendix may be trapped' between them or adherent in front or behind In any of these situations it may be impossible to see it until the ileum is empty

Pathological fixation of the cæcum or ileum to palpation is evidence only of peritoneal adhesions This may or may not be appendicular in origin and has a significance with reference to an appendicular lesion only in the presence of other signs pointing in the same direction

Fig. 108.—A kinked, stenosed, adherent appendix.

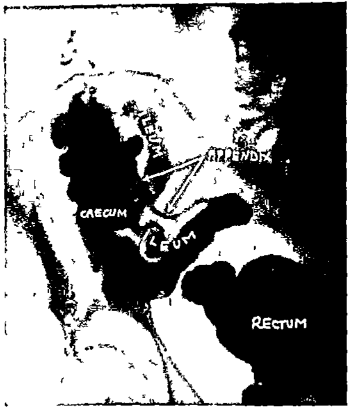


Fig. 109.—Appendix adherent across the terminal ileum: the so-called "controlling appendix."

(7) TENDERNESS ON PRESSURE OVER THE APPENDICULAR SHADOW.—This may be a sign of considerable importance and its significance depends on several factors. If the appendix is fixed the tenderness induced by pressure over it probably usually depends on a drag on the parietal peritoneum. Tenderness over a mobile appendix is elicited by deep pressure with one finger accurately over the appendix and should be obtained with the latter displaced into different positions. This tenderness localised over the appendix shadow no matter what its position and over its shadow only forms an important sign of chronic appendicitis. *Hurst* regards it as one of great value and explains the pain elicited as being due to increased visceral tension in the organ. This presupposes some damming back of the contents in the appendix. Whatever the mechanism the sign is the most reliable of all the X-ray evidence. It must be elicited and localised with careful precision. Vague general tenderness on pressure in the right iliac fossa is of no diagnostic importance. Many patients are sensitive to firm palpatory pressure in the lower abdomen and in these the corresponding area on the left side should also be palpated for comparison.

FIG. 170.—Appendicular stasis. Barium residue ten days after a barium meal.

(8) APPENDICULAR STASIS.—Retention of barium in the appendix after the cæcum is clear is regarded by *Kadrnka* and others as indicative of appendicular disease. The longer the appendix retains barium the more important is this sign. If it retains barium for three or four days after the cæcum is empty of the opaque medium a fibrotic or stenotic lesion of the appendix is probable. The importance of the sign is obviously enhanced by direct evidence of lumenal stenosis and diminished by the demonstration of a normal contour (Fig. 170).

(9) ILEAL STASIS occurs in chronic disease of the appendix if adhesions have formed of such a nature as to cause some mechanical obstruction or if the appendix itself is bound down by adhesions over the terminal ileal loop. According to some authorities it may also result from reflex closure of the ileo-cæcal sphincter. Some doubt exists on this point. *Lane* and *Jordan* have made a prolonged study of this and for years ileal stasis was regarded as an important sign of appendicular disease. A tendency also arose to find ileal

stasis where none existed These authorities attributed the stasis particularly to a kink in the juxta cæcal loop but this kink is now generally regarded to be much rarer than they held it to be In the writer's experience it is extremely rare

In the estimation of ileal stasis there is considerable variation amongst different observers According to *Hurst* the ileum is usually clear of barium four hours after the stomach is completely emptied but this time factor may be longer in some cases *Jordan* lays great stress on the fluoroscopic observation of writhing peristalsis in the ileum a phenomenon rarely met with in *the experience of others Dilatation of the last few loops of the ileum may* be of significance but again the normal may show considerable variations in this respect

In the writer's opinion considerable latitude should be allowed to the ileum in the determination of stasis therein and stasis should be diagnosed in *the absence of an obvious constricting band only if the evidence is frank* i e considerable prolongation of the time intervals considerable retention of barium and definite ileal dilatation

(10) GASTRIC STASIS —*Barclay* has described an ileo gastric reflex in which ileal stasis from disease in the appendicular region causes a reflex inhibition of *gastric evacuation with resulting stasis As gastric stasis can be due to so* many other causes its value as a sign of appendicular disease is slight

In general chronic appendicitis is a condition in the diagnosis of which clinical evidence is as important as the radiological if not more so

LOCALISED APPENDIX ABSCESS

It is seldom that opportunity presents itself to examine this condition radiologically since *the condition usually gives decisive clinical signs* In the more chronic cases however doubt may exist in the differential diagnosis between abscess carcinoma and tuberculosis of the cæcum These abscesses may vary in size from a hazel nut to an orange or larger When they reach any appreciable size they cause *a pressure defect in the barium filled cæcum* maybe an irregularity of the cæcal outline from associated typhlitis a fixation of the cæcum spasm of the cæcum (Stierlin's sign) and tenderness on palpation

A study of the thorium relief pattern shows the mucosa to be intact This *differentiates the abscess from the other two lesions mentioned above* The colonic mucosa distal from the abscess may show by the same method a state of reflex reaction or irritation

CANCER OF THE APPENDIX

This cannot be diagnosed radiographically in an early stage Any radio *graphic signs present in the early stage are those of an associated appendicular*

inflammation When the growth has begun to implicate the ileum and cæcum, the radiographic appearances proper to carcinoma in those situations will then show themselves

DIVERTICULA OF THE APPENDIX

These are rare, and occur along with, and part of, a colonic diverticulosis Theoretically they should be prone to inflammatory changes, being, as they are, blind offshoots from a narrow blind tube but on the other hand *Lockhart Mummery* states that inflammatory changes are rare in them Cases have been recorded by *Berg, Albrecht, Kadrnka,* and *Sarazin* The writer has seen one case, found in a normal appendix during a routine examination

CHAPTER XVIII

EXAMINATION OF THE COLON

THE FOLLOWING methods are available

(1) Plain radiogram
(2) Barium meal
(3) Barium enema
(4) Barium air double contrast enema
(5) Thorium-air double contrast enema

THE PLAIN RADIOGRAM

The radiogram is used to study the presence and distribution of gas and fluid in the colon in cases of subacute and acute obstruction

THE BARIUM MEAL

The barium meal followed through till the colon is clear is of particular value when the function of the colon requires investigation Occasionally it is permissible to start this examination seven hours after the ingestion of the meal but in routine work this is inadvisable unless it is quite certain the upper alimentary tract is without fault *Convenient intervals for the examination are seven hours after the meal twenty four hours thirty hours and on subsequent days as is necessary* The examination may extend over a week or longer especially in cases of chronic constipation partial obstruction and diverticulosis Barium sulphate has a tendency to cake and form scybala if retained too long in a colon and this method should not be employed when there is reason to suspect organic colonic obstruction of any degree In such a case acute obstruction might be precipitated

Fluoroscopy and radiography are both essential The former should be conducted with the patient supine the latter in the supine the prone and sometimes the erect position

THE BARIUM ENEMA

The barium enema is the sheet anchor in the X ray investigation of colonic morphology The barium meal very frequently fails to outline the colon sufficiently for a morphological study By the opaque enema however the colonic lumen can be completely outlined

Preparation —There are two desiderata in the preparation for a barium enema the colon must be voided as completely as possible of its contents fæcal and gaseous and the means taken to effect this must not leave the colon so irritable as to prevent reasonable retention of the opaque enema during the examination Castor oil 1 to 2 oz is the most generally satisfactory aperient It should be given on the day before the examination If the patient is in the habit of taking some other aperient a double dose of that may suffice If the bowel is not thoroughly cleaned out by this means a small soap and water enema on the morning of the examination may further stimulate evacuation Usually colonic lavage is necessary It should be given two hours

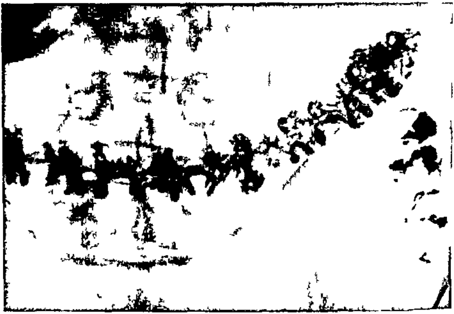


FIG 171 —Normal colon mucosal pattern 7 hours after a barium meal

before the examination to allow time for absorption of fluid retained in the upper colon The Studa chair is the best method for this

In cases in which there is clinically a strong suspicion of chronic obstruction of the colon vigorous purging is unwise and unpleasant for the patient It is better then to rely on colonic lavage The latter procedure will empty the colon as far as the point of obstruction which is all that is necessary for the satisfactory demonstration of the obstruction

The Opaque Medium —The formulæ which the writer uses are given on page 35 It should be as thin as possible consistent with proper suspension of the barium sulphate Considerable variation occurs in different brands of barium in this respect With some specimens the particles are so large that a con

siderable quantity of mucilage is necessary to hold the barium in proper emulsion, and a thick cream means unduly slow filling of the colon The colloidal preparations of barium sulphate now on the market will stay in suspension for one half to one hour, and may be used without any suspending agent They have the advantage that the mucosal pattern is better shown after evacuation and are particularly useful for the three stage barium air enema The emulsion should be warmed to blood heat before administration Several pints of cold fluid introduced into a colon is unpleasant for the patient and promotes a peristaltic reflex in the gut As much as 4 pints may be necessary to fill the colon and this amount should always be available

Apparatus —The following accessory appliances are necessary

(1) A large glass funnel capable of holding 2 pints The usual flat bottomed metal douche-can is not satisfactory as barium tends to form a sludge at the foot In addition it is difficult to see from it the rate of administration An inverted hot water bag with the stopper pierced by a hollow metal tube is *quite a convenient reservoir*

(2) Some simple form of stand to support this

(3) A length of large bore rubber tubing This is conveniently interrupted by a glass connecting tube

(4) A strong spring clip or stopcock to control the flow The stopcock may with advantage be three way, with a side tube for evacuation

(5) A rectal tube The opening in this should be terminal or close to the end and large A large size œsophageal tube serves but some form of metal self retaining enema nozzle is more satisfactory

It is of vital importance that the whole apparatus of administration be sterilised by boiling or other agent between each examination as the same tubing is used for evacuation of the enema and thus becomes contaminated

Administration —The patient is arranged on the couch so that the observer *is on his left The rectal tube empty and separate from the rest of the system,* is first introduced and the patient placed in the supine position The tube should be sufficiently long to reach down under the thigh to the patient s side The reservoir in position on its stand and the main length of tube are then filled with barium down to the glass connecting piece controlled by the *spring clip or stopcock The glass connection is then joined with the rectal* tube and the enema ready to be run in This method involves introducing a small amount of air—the amount in the rectal tube—but this objection is in the main theoretical and the advantage—that of a clean, dry administration—very practical Another point in its favour is that the reservoir is not filled until just before the enema *is run in and thus the barium has little time to* sediment and by so doing clog the tube

The disadvantage above mentioned may be minimised by placing the glass connecting piece as close to the rectal nozzle as possible The enema is then run in slowly by gravity the whole process being observed fluoroscopically

It is important to instruct the patient on three points namely, to make every effort to retain the enema to say if he experiences pain or discomfort, and to give warning of an impending leakage past the tube A flood of barium on the X ray couch is quite a devastating occurrence for all concerned (particularly for patient and nurse!) It can be foretold by any intelligent patient its beginnings observed on the screen and its progress arrested by relieving the pressure or emptying the rectum of a few ounces via the rectal tube

FIG 17 Barium enema normal colon appearance

As soon as the rectum is filled out to its normal wide contour the patient is apt to experience a desire to evacuate It is advisable then to stop the administration for a few seconds until this passes off In the majority of patients the whole colon may then be filled without further discomfort but in some intermittent administration is necessary because of recurring distress Each portion of the gut should be carefully inspected and palpated as it fills and rotation of the patient into the oblique positions is necessary to view superimposed coils in their entirety, particularly in the sigmoid and splenic flexure

Radiograms should be taken during the filling if any special point warrants and routine supine prone and oblique views after complete filling The patient is asked to retain the enema while these are developed and inspected in case they reveal some point requiring further investigation Most patients can do this but if any distress is experienced it can as a rule be relieved by emptying the rectum only and without disturbing the general filling of the colon The enema is then run off as far as possible Usually only a portion can be returned in this manner This process can be aided somewhat by pressure on the hypo

Fig 173 —Normal barium enema appearance

Fig 174 —The same, after evacuation of the enema The appendix presented an Indian club deformity and was the seat of chronic inflammation

gastrium. A further radiogram may then be taken or after the patient has retired and relieved himself in the normal manner. The mucosal pattern

FIG. 1[illegible].—Normal colon after evacuation of a barium enema. This picture fortuitously shows the appearances in the three stages of a barium air enema: from caecum to sigmoid are seen (1) the mucosal pattern in collapse, (2) the contour line in inflation, and (3) the barium filled lumen.

may sometimes be seen at this stage but in many cases no satisfactory view of it is obtained.

THE BARIUM AIR DOUBLE CONTRAST ENEMA

This may give an excellent picture of the normal colonic mucosal pattern but is rather a long process and is not always successful. The appearance of

the normal phase is similar to that described later in the thorium three-stage enema, but the abnormal phase are more erratic in their demonstration than with the latter medium Frequently the barium fails to coat the mucosa completely The method is of particular value in the demonstration of small pedunculated growths *Kirklin* recommends its use on all cases of colonic hæmorrhage in which the ordinary barium enema has failed to reveal any organic lesion The technique, as evolved by *Kirklin* is as follows

The preparation is all important, and *must* ensure complete evacuation of the bowel Two ounces of castor oil should be given on the day before, and on the morning of the examination saline colonic lavage is given until the return is clear

After the ordinary barium enema examination has been completed the patient retires and empties the bowel as far as possible On his return, a radiogram is taken of the collapsed bowel in the hope of showing the mucosal pattern There is more chance of this being achieved if the "colloidal" preparations of barium are used The colon is then filled with air by a Higginson s syringe This in turn induces a call to stool The patient again retires and the process is repeated until all the barium has been evacuated except for a thin layer coating the mucosa Two or three insufflations may be required to effect this After a final air inflation stereoscopic radiograms are taken These show the gas distended colonic walls standing out in relief and a barium coated polypoid tumour can clearly be seen projecting into the lumen A scybalon presents a closely similar appearance, hence the necessity for very thorough preparation

THE THORIUM-AIR DOUBLE CONTRAST ENEMA

Because of its simplicity, the barium sulphate enema remains the standard method of examination of the colon, but in certain cases of difficulty an investigation of the mucosal pattern by flocculent media may be helpful This is a variant of the barium air double contrast enema method described above, and the examination in this case is also in three phases (1) the filled colon, (2) the collapsed colon showing the mucosa coated by flocculation of the opaque medium, (3) the colon distended by air

The difficulty in the use of barium sulphate for this purpose is that flocculation does not occur, and the coating of the mucosa is very incomplete The labile colloidal suspensions of thorium oxide if used with proper technique, deposit themselves more satisfactorily on the surface of the mucosa and so outline it Three preparations are available, so far—*collothor*, *umbrathor* and *diagnothorine*—and all three have a common characteristic in that they are rapidly precipitated or flocculated by ordinary water Thorotrast, being a stable form of thorium dioxide, does not flocculate and is unsuitable for this purpose Flocculation should not take place too rapidly, otherwise the deposited layer may be too thick, not sufficiently elastic, and the upper reaches of the colon not

reached It depends on two factors, the exact preparation itself, and the pH of the colonic interior

Briefly, a high pH induces the deposition of an elastic layer, which readily stretches during the subsequent insufflation, while a low pH produces a flocculent layer less viscous and more apt to fragment during insufflation In theory, it might be possible to choose a medium suitable to the ascertained pH of the colonic contents in each case In practice it is simpler to adjust the latter to the medium, during the preparation of the patient by the use of colonic lavage with a solution of sodium phosphate in a strength of 10–20 per thousand The above three media act best, on the average where the colon has been washed out one hour before with this solution Diagnothorine, the medium used by the writer is sold by the makers in a strength of 25 per cent and should be diluted to the appropriate strength for use (5–10 per cent) with *distilled* water Tap water will cause an immediate precipitation

Preliminary Preparation —Because of the biophysical factors involved, this is of the utmost importance The colon must be *completely* emptied of all scybala and other contents and the mucosa cleansed of adherent mucus etc, and its pH adjusted

Maingot recommends the following preparation

(1) On the evening before the examination 1–2 oz castor oil followed by a liquid diet up to the time of the examination

(2) On the morning of the examination colonic lavage with plain water two hours before and with the above solution of sodium phosphate one hour before

Saline purges and drastic cathartics are inadvisable, since they irritate the colon and cause hyperæmia and hypermotility of its mucosa Even castor oil does this to a slight extent

The Injection —The essence is to use as little of the opaque medium as possible distension of the colon is to be avoided The administration must therefore be intermittent *Maingot* and his co workers use a special air pressure apparatus delivering a full strength or half strength solution at will, In the absence of such apparatus the solution may be administered by gravity using a glass funnel and tube or by a Higginson's syringe Whichever method is used about half a litre is sufficient to fill the whole colon The filling should be observed fluoroscopically and not more than 1–2 oz injected at a time One must avoid distending the rectum as it may not contract satisfactorily and so retain too much of the medium In this examination it is undesirable to stretch the tonicity of the colon Usually the colon fills satisfactorily as far as the right half of the transverse colon, but it is often difficult to fill the right colon Any attempt to increase the pressure of the injection must be resisted Turning the patient on the side and on the face may be successful Palpatory pressure should be guarded against, lest a mass peristaltic wave is induced

When the colon is filled to the cæcum, but with its lumen relatively con

tracted the first radiograms are taken. The patient should then lie still for ten to fifteen minutes to allow flocculation to take place. He is then instructed to empty the rectum but not to strain. It is preferable to pay two or three visits to stool since it is said by *Maingot* straining may induce secretion of colonic mucus and displace the flocculent layer. As soon as the bowel is collapsed there is not a minute to lose since mucous secretion quickly begins to displace the flocculation. The necessary radiograms should be taken at once and then the third phase, air distension, may be undertaken.

Failures in the Technique of Flocculation

NO DEPOSITION may take place at all. In this case it is best to postpone re-examination to a subsequent date, to repeat the preparation with thorough care and to use a stronger colloidal suspension. Immediate refilling with a stronger suspension is less likely to be successful.

IRREGULAR DEPOSITION.—Flocculation may take place, say, in the right colon and none in the left. Further measures will depend on the diagnostic requirements. It may be possible to proceed to immediate partial refilling with stronger suspension as in the case postulated. In some cases the partial flocculation may give the necessary information, while in others complete refilling on another day may be advisable.

FAILURE TO EMPTY.—The evacuation of the colon may be incomplete. This is prone to occur in elderly subjects, and the right colon is commonly the site of the incomplete emptying. Posture and abdominal massage may help but are sometimes ineffective. Pitressin (5 units) is sometimes effective but may provoke vigorous segmental peristalsis and destroy the mucous pattern. Prostigmine may promote satisfactory peristalsis, and in elderly patients and others in whom colonic atony is suspected 1.2 c.c. of prostigmine may be given hypodermically with advantage twenty minutes before the beginning of the examination.

Insufflation of the Colon.—As soon as satisfactory radiograms have been obtained of the collapsed mucous pattern the colon should be insufflated prior to the final radiograms. This should be done under fluoroscopic control. An artificial pneumothorax apparatus gives a convenient filling, but a Higginson's syringe manipulated gently is a satisfactory substitute.

Certain difficulties may be met with during insufflation. Ideally the whole colon should fill regularly from rectum to cæcum, but in most cases there is some variety in the distribution of gas and some of the opaque injection retained. With this one must be content.

In hypertonic strongly muscled subjects it may be difficult to distend the colon satisfactorily. If the sphincters are patulous, retention of the injected air may be impossible, although the use of a large rectal tube may help in this respect.

Radiographic Appearances in the First Stage, that of the Filled Colon — These are substantially the same as with a barium enema save that the colon is not so distended and the medium not so opaque (Fig 176)

Radiographic Appearances of the Plicæ in the Second Stage, after Collapse of the Colon —A colon will contract by virtue of its elasticity and muscular

Fig 176 Normal colon in a three stage enema First stage of filling

tonicity The narrowed lumen has to accommodate the same mucosa and the latter folds itself into plicæ (Fig 177)

TYPES OF PLICATION

(1) *Haustrations* the whole wall being involved

(2) *Mucosal Plicæ* —The mucosa is very laxly attached to the muscular coat and can form varying plicæ independently of the latter The plicæ are produced by the activity of the muscularis mucosæ and their form varies with the degree of vascularity of the submucosa the secretory activity of the mucous glands and other nervous and irritative factors

Pilocarpine contracts the gut and increases the number of plicæ Atropine has the reverse effect

FORM OF THE PLICÆ

Longitudinal folds tend to take place when the tænia are relaxed and the gut lengthened They are common in the lower sigmoid *Transverse plicæ*

occur when haustra are present. Usually both can be made out, and from these primary plicæ secondary arborisations frequently arise (Fig. 171). As in the stomach, so in the colon great variation in the normal mucosa may occur, and in the present state of our knowledge diagnosis of the pathological should be guarded.

Pathological Variations in the Mucosal Pattern.—The plicæ do not form at all unless the colon contracts and empties itself. At times collapse does not

Fig 177 —Normal thorium air enema Second stage, of collapse

occur—air in the colon prevents it; atony or hypotonia of the colon above an obstruction, and rigidity of the colonic wall are other causes. Assuming that collapse has taken place and the opportunity for flocculation and plication so provided, certain variations in the mucosal pattern may indicate pathological states. Amongst these variations are the following:

Plicæ Small and Numerous.—This is seen in the so-called "irritable" colon, a condition which *Knothe* describes as a reflex disturbance of the neuro-muscular mechanism, e g. from tuberculous peritonitis, cholecystitis, or appendicitis.

Plicæ Large and Few in Number —This results from any congestion of the mucosa, as in catarrhal colitis.

Plicæ Small, Simple in Pattern, and Few in Number —This occurs with atrophy of the mucosa

Of greater diagnostic importance than the above are certain other changes in the mucosal pattern such as

ASTERISK OR HONEYCOMB PATTERN in polyposis The clear interstices represent the polypi In diverticulitis a similar star pattern may radiate from a filled diverticulum

DISORGANISATION OF THE PATTERN —This is seen in mucous colitis and in increased degree in early ulcerative colitis

ABSENCE OF PLICÆ —This results from grave destruction of the mucosa as in advanced ulcerative colitis or neoplasm

FIG 178 Normal thorium air enema Third stage of inflation

Radiographic Appearances of the Third Stage after Inflation of the Colon with Gas —Three aspects in particular should be noted the colonic calibre the delineation of its contours and the appearance of the anterior and posterior walls seen *en face* (Fig 178)

THE COLONIC CALIBRE when insufflated is between two and three times that when filled by the thorium enema and about equal to or a little larger than that shown by the ordinary barium enema The variations from the normal are similar to those shown by the barium enema and need no further description here

THE CONTOUR LINE is of considerable importance according to *Maingot* Normally if the flocculation and distension have been successful the contour of the lumen should be outlined by a dark line 1 2 mm thick uniform and

continuous *Maingot* and his co workers lay such stress on this that they have named it the *lisère muqueux de securite*, on the hypothesis that if this line is present in unbroken continuity it excludes an ulcerative colitis Its absence is of less importance since defective flocculation or excess of mucous secretion may prevent its appearance or rapidly obliterate it, respectively

The opaque contour line may be quite absent in mucous colitis but more commonly it is broken, appearing like morse code symbols This also is inconstant as a sign and may appear in the normal subject if the flocculent layer was too inelastic to accommodate to the stretching of the insufflation

Again the marginal line may be irregular or woolly, due to excess of mucus in it In diverticulitis it shows a characteristic appearance described under that section In intrinsic tumours and developed ulcerative colitis the line is irregular and broken at the site of the lesion

THE SURFACE OF THE MUCOSA SEEN 'EN FACE' in the area bounded by the contour lines (" intermarginal area ") also merits attention Normally it should be uniform like a colour wash, if the flocculation has withstood the insufflation More commonly it cracks, and forms a mosaic, like the " crazing " in pottery ware In this mosaic the " stones " are opaque and the intervening cement is transparent In this intermarginal area various opacities may be visible such as the rounded shadows of filled diverticula and the irregular blobs of impregnated mucus in mucous colitis

Reticulation may be evident, the appearance then being the negative of the normal crazing, i e the reticulum is opaque It is irregular in type and is seen in developed ulcerative colitis with granulomatous proliferations

Polyposis shows a remarkable 'negative " mosaic appearance, the clear spaces representing the polypi Larger ones may retain a complete coating, and stand out clearly in the air filled colonic lumen

Carcinoma shows a completely disorganised irregularity in the intermarginal shadows, and the unchanging quality of this deformity is an important feature

In conclusion the thorium three stage enema is a new method, and is not infrequently unsuccessful The technique is difficult, but further experience may indicate modifications which will improve the percentage of successful administrations It appears at present to be of value chiefly in cases of colitis and colonic hæmorrhage in which the older methods fail to give definite radiological signs, and its precise value as a method is yet to be finally assessed

CHAPTER XIX

ANATOMY AND PHYSIOLOGY OF THE COLON

ANATOMY OF THE LARGE INTESTINE

THE LARGE intestine consists of the cæcum the colon and the rectum Its anatomy and general arrangement in the abdomen do not need detailed description except for some points of radiological importance Its average length is 5 feet and its width varies from 2 to 3 inches The widest part is the cæcum and it gradually narrows towards the rectum

THE CÆCUM the widest and most distensible portion with the exception of the rectum is usually situated in the right iliac fossa but it is subject to great variation in this respect depending on the length of its mesentery and the habitus of the individual In hypersthenic subjects it may be high up in the fossa and in hyposthenics deep in the pelvis It is normally freely mobile on palpation but in about 5 per cent of cases it possesses no mesentery and is then relatively fixed This variation must be borne in mind in the diagnosis of cæcal adhesions

THE ASCENDING COLON is continuous with the cæcum and runs upwards to end at the hepatic flexure The ascending colon is said to have no mesentery and to be bare of peritoneum posteriorly but in spite of this it displays a surprising degree of mobility The forward and medial bend of the gut which forms the HEPATIC FLEXURE has no firm attachment above and its position varies markedly with posture In the erect position it is usually just above the iliac crest and in the supine 1 2 inches higher

THE TRANSVERSE COLON has a long mesentery and is subject to great variation in position It may pursue a relatively straight course between the flexures or hang in a pendent loop into the pelvis

THE SPLENIC FLEXURE occupies a position high under the left dome of the diaphragm It is in respect of its position the most constant part of the upper colon being anchored there by the costo colic ligament Occasionally it is seen lower in position but this is held by some to be always pathological Indeed if there be any true radiological sign of Glenard s disease it is marked descent of this flexure

THE DESCENDING AND ILIAC PORTIONS OF THE COLON drop down from the splenic flexure to the true brim of the pelvis As a rule they have no mesentery but in spite of this considerable lateral mobility is normally present They are the narrowest portions of the colon

THE PELVIC COLON has a mesentery which when spread out curves the gut

in sigmoid form. This portion is therefore freely mobile, and very varied in its disposition. In some cases the mesentery is short, in others it is long and allows of a large sigmoid loop. At its termination it is directed backwards and then downwards to form the rectosigmoidal junction. It therefore lies in front of the upper part of the rectum.

THE MUSCULAR COAT of the colon is composed of an internal continuous circular layer and three outer longitudinal bands, the *tænia coli*. The tonic

FIG. 179.—Normal colon 7 hours after a barium meal, showing the trefoil arrangement of the haustral pockets, due to the disposition of the tænia coli

contraction of these bands helps to form the haustral sacculations of the resting colon. These haustrations are largest in the cæcum and ascending colon, most regularly formed in the transverse colon (where they may be *literally geometrical*), *and gradually disappear as the sigmoid is reached.* Each haustral segment is typically trefoil when viewed in cross section (Fig. 179).

FUNCTION OF THE LARGE INTESTINE

The function of the colon with which the radiologist is particularly concerned is, in the main, *motor*; its method of filling, and its tonic and peristaltic activity.

This is best studied by the barium meal.

Filling of the Cæcum and Upper Colon.—In spite of the countless screen examinations which have been made on subjects and patients, this still remains

something of a mystery A colon is viewed, say, two to three hours after a barium meal, and some of the opaque medium is seen in the cæcum Two hours later, the colon may be filled with barium as far as the middle of the transverse portion, yet repeated screen examinations during that interval would fail to reveal any appreciable movement in the contents of the gut

The explanation lies, I think, in three factors (1) The regular intermittent passage of small quantities of chyme from the ileum into the cæcum (2) The fluid nature of this chyme (3) The tonicity of the bowel

When fluid contents pass into the cæcum the tonicity of the latter tends to force them a certain distance along the colon, depending on the amount of fluid and degree of tonicity This is a very slow process and can be likened to a very slowly administered barium enema so slow that the onward progress of the head of the barium column cannot be appreciated The process is arrested gradually by the activity of a function of the upper and right portion of the colon—that of resorption of water As the contents become semi solid and then pultaceous this onward progression ceases, and a different form of activity takes change the mass movement

Mass Movement—This form of peristaltic activity first described by *Holzknecht* over twenty years ago, is now accepted as the only normal method of transporting the contents of the upper right colon towards the rectum

The term "upper right colon" is coined to indicate that portion of the large intestine in which the resorptive process takes place It extends from the cæcum to about two thirds along the transverse colon The colon from about the splenic flexure to the rectosigmoidal junction is different in function While the former may be regarded as a reservoir the latter as *Gaskell* has described it is a transmitting segment of exaggerated irritability Its normal state is that of emptiness Haustral sacculations the object of which is to increase the area of absorption, are poorly marked in the left colon, where the necessity for them is less Whenever a fæcal bolus is delivered to this portion over the splenic flexure, the tendency is for it to be swept down into the rectum

To return to the mass movement the sequence of events is as follows first of all the haustral contractions over a considerable segment of say the transverse colon disappear and the barium shadow has a ribbon like outline This change occurs very rapidly in two to three seconds At the same time a constriction appears proximal to the fæcal mass, usually in the region of the hepatic flexure *Barclay* has stressed the importance of this constriction which he terms the *point d appui*, and is of the opinion that on its competency depends the successful transference of the fæcal mass along the colon The more liquid the mass is the greater the importance of this to prevent reflux into the lax ascending colon and cæcum This constriction really marks the starting point of the strong peristaltic wave which sweeps the colonic contents on towards the rectum The whole process is over in a short time

In about ten to twenty seconds the mass may reach the descending or sigmoid colon The mass movement may be arrested for a few moments when the iliac colon is reached and then continue until the mass is in the rectum

A few seconds after the reflex is completed haustral contractions reappear, and as *Barclay* puts it the general picture of still life is restored

Not uncommonly a radiogram taken after a mass movement has taken place will show a snail track of barium along the empty colon along which the transference has taken place This is a common appearance in cases of mucous colitis—*Crane's* string sign—but occurs also in the normal

In the perfect physiological reflex the portion of gut involved in the wave should be emptied completely but frequently some fragments are left in the wake This is particularly apt to happen if there has been a tendency to constipation and formation of scybala

These mass movements occur infrequently, two or three times a day, and vary in the extent of their travel Some reach the sigmoid or rectum and some the descending colon the mass left there being dealt with by a subsequent reflex some hours later Only when the rectum is reached is a call to stool experienced

Other Movements

THE PENDULUM MOVEMENT OF RIEDER —This observer has described to and fro movements of the contents of quite a large segment of the bowel The object is supposed to be to churn the contents It is said to be an established phenomenon but it is extremely rarely seen The writer has not come across it in thousands of screen examinations although he has observed the mass movement on many occasions

ANTIPERISTALSIS —*Case* has recorded cases of antiperistalsis in the colon It is possible that this occurs behind an obstruction in the upper colon and often occurs in a colon which is trying to rid itself of a barium enema against the patient's wishes but it is doubtful if it occurs in the normal apart from such forcible voluntary restraint of defæcation

HAUSTRAL CHURNING —This has been described by *Samson Wright Cole* and others It occurs especially in the cæcum ascending and proximal transverse colon and consists of slow alterations in the degree of the haustration They are too slow to be detected with certainty on screen examination, but can be seen in serial radiograms

RATE OF TRANSIT THROUGH THE LARGE INTESTINE

This varies enormously in different individuals and obviously depends on the number and extent of the mass movements which take place in the twenty four hours Taking as a standard the subject who defæcates once a day, the rate of progress of a barium meal is somewhat as follows

In three hours the cæcum is filled in five to six hours the head of the barium is in the region of the hepatic flexure or proximal transverse colon, in twelve hours it is about the splenic flexure By twenty four hours half of the barium may have been evacuated and the remainder rather scattered with traces in the cæcum and ascending colon and some in the sigmoid From the distal position of the transverse colon to the iliac colon is usually clear By forty eight hours none should remain

In those of more active colonic habit these times may be greatly shortened It is not uncommon to find barium in the rectum two to four hours after ingestion especially in circumstances of nervous stress It was *Trousseau* who first drew attention to the tendency to hypermotility and diarrhœa in the neuroses

A more common occurrence however is to find these times lengthened and while such a state of affairs is often labelled as stasis it is important to bear in mind that that stasis may be physiological

CHAPTER XX

ANATOMICAL VARIATIONS OF THE COLON

THESE MAY be classified in the following manner

- Anomalies of length
- Anomalies of rotation
- Anomalies of fixation
- Anomalies of size
- Anomalies due to adhesions and herniæ

ANOMALIES OF LENGTH

The Short Colon, with high position straight gut between the flexures, and a small sigmoid is of little clinical significance since it is seldom associated with physiological dysfunction The writer's impression is that colospasm is more common in this type than in the hypotonic individual

The Long Colon, redundant colon, or dolichocolon of the continental writers, is according to *Kantor*, frequently associated with a clinical syndrome consisting of constipation gaseous distension, and abdominal pain the autointoxication of *Arbuthnot Lane* (Fig 180)

Kantor describes the following criteria

The long pelvic loop rises well above the intercristal line It may be placed medially, or to the right or left

The redundant descending colon is commonly coiled or reduplicated, the transverse colon deeply festooned or convoluted and the ascending colon doubled

The redundant colon can cause considerable discomfort to the patient and trouble to the radiologist if the upper colon is distended with gas, to the former by flatulent discomfort and to the latter by making gastric examination difficult When distended with gas it can produce the various stages of cascade stomach bilocculated stomach, and volvulus in both planes

Subphrenic Displacement of the Colon (*Syn* **Hepato-diaphragmatic Interposition)**

Frequently the gas filled transverse colon may be seen, in cases of the long axial gastric rotation crossing *in front of the latter*, and up between the liver and the right cupola—the so called falciform colon (Fig 181) *Graham Hodgson* in a personal communication records a case in which the falciform ligament was found at operation to be absent This hepato-diaphragmatic interposition may be temporary, or may become fixed The upward displacement may also be posterior to the liver

Fig 180 Normal barium enema appearance in a colon of the redundant type

Fig 181 Anterior hepatodiaphragmatic interposition of the colon

A vicious circle may be established in these cases, the gas tends to float the gut up to the diaphragm, and the position tends to prevent the onward passage of the gas It is possible that pitressin might be of help in this condition an important one because of the symptoms produced, the gastric deformity it produces and the way in which it may simulate at times free gas under the right dome

ANOMALIES OF ROTATION

The most severe degree of failure on the part of the embryonic intestinal rotation is known as—

Situs Inversus Partialis Commune Mesenterium —In this congenital variation the small intestine occupies the right abdomen and the colon the left Both have a common mesentery, and the colon is very mobile The liver, *spleen pancreas and stomach are normal The duodenum instead of curving* round to the duodeno jejunal flexure makes a loop to the right and joins the jejunum on the right side below the liver The ileum lies below the jejunum, in the right iliac fossa The terminal ileum runs across the midline to join the cæcum, the ileo cæcal junction is on the right cæcal wall The variable *portion of the colon in these cases is from cæcum to splenic flexure A usual* arrangement is that the cæcum lies near the left iliac fossa anterior to the iliac colon the ascending colon runs upwards and bends over into a looped or folded transverse colon It is as though the right half of the colon has been displaced concertina wise towards the left half, and lies more or less *in front of it*

This arrangement may be made out both by a barium meal and enema Cases of congenital abnormality of this type are said to be more liable to the formation of obstructive bands and kinks than normal individuals

Embryology —This abnormality is the result of a failure of the normal rotation of the gut during early intra uterine life (Fig 182) During the first five weeks of life, the mid gut, supported by the superior mesenteric artery, *herniates through the umbilicus into the cord At the ' apex of the loop of* herniated gut are attached the vitelline artery and duct (the site of Meckel s diverticulum) These divide the gut into pre and post arterial parts Rotation of the gut begins about the tenth week

At first the pre arterial segment (small intestine) lies to the right and the post arterial to the left Rotation occurs with the gradual return of the gut into the abdominal cavity The pre arterial segment leads and as it returns it passes *under the superior mesenteric artery and pushes that part of the post* arterial or colonic segment which was not herniated to the left there to form the left half of the colon

The cæcum is the last to be returned At first it lies in the midline anterior to the small intestine As the transverse colon develops the cæcum travels *first to the right hypochondrium and then down to the right iliac fossa* It

may halt in the former position, and represent the variation known as the *undescended cæcum*

In the abnormality under discussion, the small intestine fails to pass under the superior mesenteric artery, but remains in the right abdomen. There is thus no duodenal loop. Similarly, the cæcum fails to perform its semicircular tour to the right iliac fossa, and remains either in the midline, or just to the left as above described (Fig 183)

Minor Abnormalities of Rotation—The minor failures result in the *undescended cæcum*. This may be subhepatic—a rare site—but the cæcum more commonly descends to a point where its apex is at the iliac crest in the prone

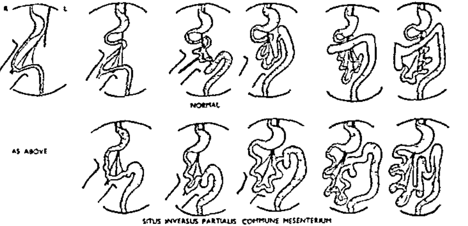


FIG 192—Diagram illustrating the development of the normal gut and the gut in situs inversus respectively

position and in the upper part of the right iliac fossa when erect. It has no clinical significance. Not an uncommon abnormality is the upturned cæcum. Two views obtain as to the ætiology of this ectopia (1) congenital; and (2) adhesions. Doubtless both occur

Kantor describes a condition of *hyperdescent*, in which the cæcum is in the pelvis in *the absence of visceroptosis*. He states that a clinical syndrome is commonly met with in association with it, reflex vomiting, toxic headaches and dragging pain in the right iliac fossa, and that the appendix is frequently removed in these cases through a mistaken diagnosis of chronic appendicitis

Transposition of the Abdominal Viscera—It may be important to recognise this interesting congenital variation if an abdominal operation is contemplated. It may or may not be accompanied by transposition of the thoracic viscera. It is of course, very easily recognised on screen examination, but in a radiogram only if the right and left sides of the film have been marked. As this is not usually done in barium meal examinations, a particular record should be made when the abnormality is noted on fluoroscopy

(a)

(b)

Fig 183—Two cases of situs inversus partialis (a) shown by a barium meal and (b) by a barium enema

ANOMALIES OF FIXATION

The colon tends to be relatively fixed in hypersthenic individuals a happy state of affairs in them since it is the other extreme that is associated with symptoms Coloptosis is bound up with the subject of Glenard s disease each of which must be clearly differentiated from the other

VISCEROPTOSIS

(*Syn* enteroptosis splanchnoptosis Glenard s disease)

Glenard in 1886 first described this condition as a clinical entity It is in essence a symptom group associated with laxity of the peritoneal and mesenteric attachments so that the stomach the intestines the kidneys the liver and spleen prolapse to a lower level than that which they normally occupy The organs most commonly affected are the stomach colon and right kidney Radiography has shown that there are three groups of cases in which the abdominal organs are low in position and it is important to differentiate between them

(*a*) **Normal Individuals of a Hyposthenic Habitus** —A low position of the viscera is normal in these subjects and is not inconsistent with perfect health and vigorous athletic pursuits

(*b*) **Cases in which True Ptosis is present,** dependent on relaxation of the abdominal wall from repeated pregnancies or other cause Frequently an extreme degree of prolapse may exist without symptoms

(*c*) **True Glenard s Disease** —These cases occur in patients of hyposthenic habitus and are especially associated with the neuroses Such patients are usually thin and lacking in abdominal fat and any factor which tends to impair their general health is apt to precipitate the development of the symptom complex An essential feature of the disease is the symptomatology In addition to the general neurasthenic symptoms there are present those referable to the prolapsed organs Prominent among these are a sense of weight and dragging in the abdomen aggravated by exercise and relieved by lying down and symptoms of nervous dyspepsia such as fullness flatulence epigastric discomfort and nausea after eating and sometimes actual pain Constipation is the rule and there may be an associated mucous colitis

It is obvious therefore that the X ray evidence of abdominal ptosis requires the corroboration of the clinical picture before true Glenard s disease can be diagnosed and even if the X ray signs are present it is unwise to stress them to the patient of neurasthenic type lest symptoms referable to them be conjured up and perpetuated Many authorities hold the view that the dropped position of the viscera is not the cause of the symptoms but that it is merely an incident in the general condition Even so the radiographic appearances give an indication of its existence and by excluding the presence of any more serious organic lesion help in arriving at the correct diagnosis

Radiological Features —*There are certain landmarks in this respect which* are of help in differentiating between the normal hyposthenic position and true ptosis

STOMACH —This organ if hypotonic may simulate ptosis from the sagging of the greater curve The position of its lower pole varies greatly in different individuals and also from day to day in the same subject This variation is *due to varying tone and has nothing to do with the peritoneal attachments of* the stomach In true gastroptosis the descent is due to stretching or increasing laxity of the gastro hepatic omentum and is indicated by the position of the lesser curve and pylorus If the incisura angularis is below the intercristal line in the erect posture the stomach may be said to be ptosed

THE DUODENUM other than the bulb may take no part in this dropping *in which case the bulb is frequently narrow and elongated* More commonly the whole loop together with the head of the pancreas is prolapsed

THE SMALL INTESTINE is normally so variable in position that it presents no satisfactory criterion of ptosis

THE COLON is more frequently displaced downwards than any other viscus The transverse colon is so often in the form of a dependent loop that no significance attaches to it The position of the splenic flexure is much the safest criterion of coloptosis Normally this is fairly constant in site in the left diaphragmatic cupola and its descent towards the iliac crest is always an index of ptosis The right half of the colon is so variable in position that only gross displacement downwards is of importance Another *characteristic feature of coloptosis is the tendency of the colon to become* slightly crowded towards the midline like a concertina The transverse colon assumes an undulating shape and the flexures are not so far apart as in the normal

THE CÆCUM may show a marked mobility and considerable variation in position in the erect and supine postures This variation or shift on change *from the erect to the supine posture is much greater than in the normal* *Kantor* regards a shift of more than 3 inches on the right side as an indication of what he calls hypofixation An antero posterior radiogram taken with the patient lying on his left side (the central ray being horizontal) will demonstrate the cæcal mobility in the form of a displacement towards the midline *This is however rarely necessary radioscopic palpation in the supine* position is nearly always sufficient to demonstrate the degree of lateral cæcal mobility

THE LIVER when it descends in visceroptosis tends to rotate forwards and casts a larger shadow from above downwards This has its clinical counterpart *in increase of the liver dullness downwards and is liable to be mistaken for* enlargement of the organ

THE SPLEEN does not cast a very defined shadow but sufficient can usually be made out to detect any marked ptosis of it

ANOMALIES OF SIZE

Congenital Dilatation of the Colon (*syn* Megacolon Hirschsprung's disease) —This condition is characterised by a varying degree of dilatation and hypertrophy of the colon without any causal organic obstruction and obstinate constipation dating from birth The more severe cases are met with in young children lesser degrees of dilatation often survive to adult life

MORBID ANATOMY —The dilatation may involve the whole or part of the colon When only part is involved the dilatation extends for a varying distance up the colon The cæcum is the portion which most commonly escapes The rectum is not involved nor is the small intestine

In addition to the dilatation the colon is elongated This is apparent particularly in the sigmoid the segment most constantly affected *Mega sigmoid* when marked results in the sigmoid loop extending far up into the abdomen not uncommonly into the left hypochondrium The bowel wall also shows muscular hypertrophy and in long standing cases fibrous hyperplasia The obstinate stasis that occurs in this condition may lead to stercoral ulceration

ÆTIOLOGY —The pathogenesis of the condition was quite obscure until *Hurst* pointed out its similarity to œsophagectasia in cardiospasm and included it in the list of disorders resulting from derangement of the sympathetic neuromuscular mechanism The writer recently saw a case in a boy of 6 associated with gross double hydronephrosis hydro ureter and vesical dilatation Further proof of the truth of *Hurst's* theory is given by the successful results—sometimes dramatic—of abdominal sympathectomy in these cases an operation which has greatly improved the prognosis of Hirschsprung's disease

CLINICAL FEATURES —The more marked cases are usually recognised during the first year of life These frequently succumb at an early age from toxæmia or perforation The milder degrees may escape recognition till later childhood or early adult life The usual symptom is obstinate constipation dating from birth, and gradually increasing abdominal distension Tympanites is very common and if ulceration has occurred diarrhœa may alternate with the constipation Scybala nearly always form in the dilated gut and it is usually very difficult to empty the colon completely either by purgatives or enemata The child shows general signs of chronic toxæmia and the general nutrition is defective contrasting with the large abdomen

RADIOLOGICAL FEATURES —Because of the gaseous distension of the colon that is usually present a plain radiogram often demonstrates the dilated coils clearly but does not show enough detail to differentiate a moderate degree of Hirschsprung's disease from obstructive colonic dilatation

The barium meal should never be used in the investigation of these cases because of the difficulty of getting rid of the inspissated barium If it is used an obstinate stasis is evident together with marked colonic dilatation The

barium occupies only a portion of the lumen in any segment surrounded by considerable collections of gas

The barium enema is the method of choice In the milder degrees of congenital dilatation it is possible and not injurious to fill the whole colon and *in those cases where the dilatation although gross is limited to the lower part* of the colon it is also permissible In marked cases involving the whole of the large gut it is neither possible nor desirable The capacity of the colon may then be anything from 5 to 10 pints or more It is the writer s practice *not to introduce more than 4 pints and to rely on gaseous contents to outline* the upper portion Changes of posture e g prone and right lateral may aid in filling the upper colon

The appearances are typical in a marked case The enema fills the rectum out to its normal size and when the sigmoid is outlined it is seen to be approximately equal in calibre to the rectum Haustrations are either absent or very slight The sigmoid loop may be very long and in the form of an acute ∩ *with the bend in the upper abdomen After the sigmoid has been filled* some of the barium passes into the colon above but usually gaseous contents therein prevent complete filling It is rare for the barium to reach farther than the splenic flexure in these advanced cases

In the less marked cases the whole colon can usually be shown by a barium enema and in addition to the dilatation the haustra are wide and rather shallow (Fig 184)

Two forms of volvulus are apt to take place in megacolon (*a*) volvulus of the sigmoid and (*b*) secondary volvulus of the stomach either along its long or its transverse axis Both are described elsewhere

RADIOGRAPHIC APPEARANCES AFTER SYMPATHECTOMY —Three operations are at present *in vogue* (1) *removal of the 2nd 3rd and 4th lumbar sympa* thetic ganglia on both sides with the connecting rami (2) resection of the mesially directed branches of these ganglia only (*Telford* and *Stopford*) and (3) periarterial sympathectomy by stripping off the plexus surrounding the first inch of the inferior mesenteric artery In the latter operation the ascending branch from the sacral autonomic plexus which joins the arterial plexus must not be cut If it is the operation will fail to improve the condition

Of these operations the last is if anything more in favour at the time of writing but satisfactory results are obtained by all and also failures

The radiographic appearances after operation are variable In some successful cases there is a marked diminution in the colonic calibre (Fig 184)

In others there is no appreciable diminution when filled by a barium enema in spite of an excellent physiological result *Persistence of the dilatation after* operation therefore does not indicate that the operation has been unsuccessful In these a barium meal gives a truer picture of the real state of affairs

Other operations which are performed on occasion are colectomy, complete or partial, and ileo sigmoidostomy (Fig 185)

Cœliac Disease (*syn* Gee's disease, Herter's disease, idiopathic steatorrhœa)

This is a chronic disorder of nutrition, characterised by wasting, abdominal distension and frequent pallid stools The essential feature is an

(*a*) (*b*)

FIG 184 Hirschsprung's disease (*a*) before operation (*b*) 18 mos after successful lumbar sympathectomy showing marked diminution in the calibre of the colon

intolerance of fats and carbohydrates in the diet The cause is uncertain The intestinal mucosa may be atrophic and the small and large intestines (particularly the latter) dilated The condition is usually met with in children between 1 and 5 years of age It also occurs in adults

Radiological Features

INFANTS —*R Gilbert* and *L Babaiantz* have investigated the radiological appearances in infants and have described changes both in the motility of the small intestine and in the calibre of the colon The transit of a meal through the small intestine may be unduly rapid in early cases but in the later stages it is usually delayed These writers also noted an irregularity in the rate both in the small and large intestines At one time jejunal and ileal transit may be

rapid and at another stasis may occur. Similarly the colonic activity may vary between stasis and frequent but tiny evacuations.

Both the large and small intestines are usually dilated, particularly the latter. This may be demonstrated by a barium meal and in the case of the colon by a barium enema. There is a tendency to irregular flecking of the small intestine, the barium being distributed in separate distended coils with gaps between. The colonic shadow when seen by a barium meal may be mottled from mixture of translucent and opaque contents.

FIG 183.—Colectomy and ileosigmoidostomy for Hirschsprung's disease: appearance [illegible] hours after a barium meal. Note the dilated ileum.

ADULTS.—According to *A. M. Snell* and *J. D. Camp* the small intestine shows definite radiological changes when investigated by a barium meal. In three cases which they report transit through the jejunum was delayed and the normal feathery markings in the gut were absent. In place of the latter the barium was disposed in aggregated elongated masses along the jejunum. These writers attribute this appearance to the presence of inflammatory changes in the mucosa and submucosa and to the abolition of the normal activity of the muscularis mucosae.

T. Izod Bennett, D. Hunter and *J. M. Vaughan* have described fifteen cases in adolescents and adults. The clinical features in these cases were fatty stools with or without diarrhœa, tetany, anæmia, skin lesions, infantilism, osteomalacia and colonic dilatation. In eight cases examined with a barium enema six showed colonic dilatation varying from a moderate enlargement of the descending portion to an extreme megacolon.

Th E Hess Thayson found colonic dilatation in four out of five adult cases examined and noted that this dilatation began in the sigmoid and gradually extended upwards

Franconi has stated that if the colon is thoroughly emptied by lavage it temporarily assumes a normal calibre

There remain to be described some of the rarer gross congenital defects which are often incompatible with life Amongst these are absence of entire colon or part thereof double barrelled colon, and micro colon

Absence of Colon —The entire colon rectum and anus may fail to develop but more commonly only a portion is involved The cæcum may be absent and the ileum pass directly into the ascending colon without the usual sphincter or the right colon may be absent and the ileum be joined to the transverse colon

If a large part of the colon is absent an umbilical fæcal fistula may be present—via a patent Meckel s diverticulum

Double-barrelled Colon —This is extremely rare *Lockwood* has reported a case of a descending colon with a double lumen each patent at both ends One lumen the larger performed the colonic function

Micro colon —This too is a rare congenital abnormality which is usually incompatible with life It may be partial or total *Fyfe* and *Lardennois* have each reported a case of total congenital micro colon the lumen being narrowed to a few millimetres

D M Greig has made an exhaustive study of four cases and points out that the colon may also be ectopic (e g the cæcum near the site of the normal splenic flexure) and also that the lower ileum may be considerably dilated

F B Stephenson also records two cases Both showed incomplete rotation of the colon In one the cæcum was subhepatic, in the other sub splenic In the latter the ileum was grossly dilated and the colonic lumen was 5 mm in diameter The rectum was also indistensible Both cases died shortly after birth

ANOMALIES DUE TO ADHESIONS AND HERNIÆ

Peritoneal Adhesions involving the Colon

Peritoneal adhesions between adjacent coils of intestine and between them and the parietes are very common much more so than would appear from X ray examination

The great majority of adhesions are symptomless and give no radiographic sign of their existence A small percentage give rise to symptoms but are undemonstrable and a still smaller percentage cause symptoms and can also be shown radiologically

The X ray demonstration of adhesions of the colon depends on three effects of the adhesion fixation of the adherent viscus, deformity of its contours,

and obstruction to the onward passage of its contents. At the same time the mucous pattern of the colon should remain intact (Figs 186–187).

Fixation of the colon by adhesions can be demonstrated only if the viscus is *normally mobile and if it is accessible to radioscopic manipulation*. The cæcum fulfils both these conditions, and fixation of this viscus is a reasonably strong indication of pericæcal adhesions. This constitutes one of the accessory signs of appendicular disease. The ascending colon, hepatic flexure and proximal two thirds of the transverse colon are similarly accessible to the palpating hands and are usually mobile, but the hepatic flexure may have no mesocolon

Fig 188—A case of sigmoid obstruction in a patient aged 6. Thought at first to be a carcinoma, the empty phase of the thorium enema showed a normal mucous pattern and indicated a simple lesion. At operation obstructing adhesions were found.

and so have little mobility, while hypertonic abdominal muscles may prevent free manipulation of the transverse colon. The splenic flexure is far out of reach of the palpating hand unless it is ptosed, and adhesions in this region, e.g. from perisplenitis, cannot be detected radiologically unless they cause obstruction. The descending and iliac portions can again be palpated satisfactorily, *but the pelvic loop is frequently placed too deeply in the pelvic basin* for this purpose.

The deformation of contour most typical of adhesions is an abrupt angulation. This angulation must be a real one, that is, it must be distinguished from a rounded bend in the gut viewed end on. Such an angulation is usually

accompanied by some narrowing or compression of the colonic lumen, which if marked, produces the third sign, *obstruction of the lumen* It should be noted that an adhesive obstruction of necessity shows fixation also, and probably deformity or angulation It is extremely unlikely that an obstructed colon which is mobile at the point of obstruction is due to an adhesion band

'Adhesions' is a diagnosis to be shunned except on clear evidence It is a non committal diagnosis one that nowadays seldom leads to operative interference except in very definite obstructive cases, and one that comes too easily to the pen of those expected to solve the mystery of the patient's symptoms by X ray examination It is still a regrettably common diagnosis on slender evidence and more commonly wrong than right

(a) (b)

FIG 187 —A case of adhesions from calculous perinephritis (a) Filling defect in the descending colon with the barium enema simulating a carcinoma (b) After air inflation mucous pattern showing in the stenosed segment

Herniation of the Colon —The splenic flexure is not uncommonly present in a left diaphragmatic hernia and always in Petit's eventration The transverse colon may occupy a ventral or umbilical hernia and the cæcum and or sigmoid be present in the inguinal and femoral varieties

CHAPTER XXI

LAMMATORY DISEASES OF THE COLON

SIMPLE COLITIS

COLITIS is a term applied to many varied conditions, from the so called irritable spastic colon to the graver forms of ulcerative colitis. Obviously the radiological picture must vary according to the type that is present. The radiological separation of the various types has been assisted by the adoption of the thorium three stage enema.

Irritable Colon : Colospasm

The simplest type is the reflex neuro muscular and vascular disturbance described by *Maingot* as the *état irritatif* and commonly *termed in this country* colospasm or the "irritable" colon. The adjective "irritable," thus loosely used, is *meant to indicate a state of affairs in which the colon tends to a state* of muscular hypertonus and hyperactivity of the muscularis mucosæ. It is *said to result from many intrinsic and extrinsic abdominal lesions*, and also from numerous remote constitutional disturbances. *Maingot* has compiled a formidable list of causative factors. Amongst the general factors he groups nervous, endocrine, and allergic disturbances, leukæmia, drugs, such as pilocarpine and purges, and general toxic states.

Amongst abdominal causative factors, he includes almost any lesion that can occur in the abdomen.

RADIOGRAPHIC FEATURES.—*The barium enema* shows a relatively hypertonic small bored colon with fine haustral contractions. This is particularly so in the left half of the colon, and in those cases which are so commonly labelled colospasm on radiographic examination the enema may be completely arrested by a temporary spasm of quite a long segment of the iliac or descending portion of the colon. After a little this usually relaxes enough to allow the upward passage of the medium.

The thorium triple method gives characteristic signs by which this colonic syndrome or reaction may be recognised. The mucosal pattern after emptying shows the plicæ to be smaller and more numerous. In addition to the normal transverse plicæ there are added secondary arborisations which make a close-set and complicated pattern.

This change is supposed to be the result of stimulation and increased activity of the muscularis mucosæ. *Pari passu* with this some increased vascularity may be present. This causes thickening of the plicæ, and represents the so called *état exudatif*.

Most commonly a mixed reaction takes place and with the secretion of excess of mucus the picture is that of simple mucous colitis

Mucous Colitis

The radiographic features of mucous colitis are slight and inconstant or absent altogether in a barium meal or enema examination but with a thorium air or barium air enema more definite changes may be detected

With the barium meal constipation and formation of scybala are common concomitants but they are not essential parts of the radiological syndrome rather are they commonly associated states A not infrequent appearance is the change known as *Crane's* string sign This is a streak or snail track of barium laid down in the lumen of the empty colon in the trail of a mass movement It is a variable and unreliable sign since it may be present not only in this condition but also in developed ulcerative colitis and in the normal subject It may extend over a foot or more of the colon and is most commonly seen in the descending portion

Fig 188—Thorium-air enema second stage showing the increased complexity of the mucous pattern in a case of mucous colitis

With the barium enema usually no changes are apparent unless there be some hypertonicity of the muscular coats again especially on the left side and some fine haustration In some cases adherent mucus causes fine irregularities in the barium filled contour of the gut These disappear after thorough preparation a point which distinguishes the condition from ulcerative colitis in which the irregularities are persistent

The thorium-air enema shows a similar appearance in the first stage that of filling The collapsed lumen typically shows increase in number and thickening of the plicæ with a tendency to formation of opaque blobs at points (Fig 188) After distension with air these thorium coated drops of mucus can be seen adhering to the mucosa *en face* and in profile A similar appearance may be with the barium air enema after inflation

ULCERATIVE COLITIS

Ætiology—Ulcerative colitis may result from a variety of causes such as (1) Specific Infections among the principal of which are amœbic and

bacillary dysentery, the typhoid-paratyphoid group, lamblia, tuberculosis and syphilis.

(2) CONSTITUTIONAL: secondary to Bright's disease, gout or plumbism.

(3) STERCORAL ULCERATION: especially above a stricture.

(4) VASCULAR: following vascular disturbances such as portal obstruction or mesenteric embolus.

(5) PARAPLEGIC.

With the exception of the tuberculous and syphilitic groups, the specific forms of ulcerative colitis tend to become secondarily infected and to merge into the non-specific type.

The bacteriology of the non-specific type is obscure. The most serious and acute cases are said to be the result of streptococcal or pneumococcal infection, but usually a variety of organisms is present.

Fig. 189.—Third stage of a lar[illegible] in a case of [illegible] colitis.

Pathology. — Three stages may be recognised in the condition: the stage of onset, the developed stage, and the stage of advanced fibrosis. The three stages show different radiological features depending on the pathological changes.

In the first stage the mucosa is swollen and congested and the submucosa shows lymphocytic infiltration. Miliary submucous abscesses develop. When these break down, tiny ulcers form, and as these increase in size *the second stage* is reached. The submucous coat becomes thickened and œdematous and the lymphocytic infiltration increases, leading to minute hæmorrhages. The ulcer margins may become undermined, and if an abscess develops between the muscular coats a "collar-stud" cavity or false diverticulum may occur. The ulcers tend to develop in the haustral sacculations. In widespread confluent ulceration the remains of the mucosa [illegible]

(a) (b)

(c) (d)

Fig. 190.—A case of ulcerative sigmoiditis proved by sigmoidoscopy.

(a) Barium enema reveals no abnormality. (b), (c) and (d) show the characteristic signs by a thorium three-stage enema—the woolly outline in the first stage, the absence of a mucosal pattern in the second, and the irregular contour line in the third.

FIG. 191.—Ulcerative colitis, second stage, with "shaggy" contour, from multiple deep ulcers and mucosal œdema. The "double contour" effect is visible.

FIG. 192.—Gross ulcerative colitis, with polypoid formation and structures. Seven hours after an opaque meal.

produce a naked-eye appearance like a honeycomb An important feature of this stage, from the radiological point of view, is the relative loss of elasticity of the bowel wall, the result of infiltration of the submucosa and muscularis *Restitutio ad integrum* can take place only if cure is achieved in the early stages In later stages healing takes place, if at all, with fibrosis In chronic late cases there is often a mixture of mucosal granulomatous nodular or polypoidal formation, with submucous and muscular fibrosis and scarring Both of these are radiologically important

Sooner or later in *advanced cases,* cicatricial contracture causes localised stricture or general contracture of the bowel and if a cæcostomy has been performed the colonic lumen may become completely obliterated This last occurrence is demonstrated by the failure to introduce a thin barium cream or thorium suspension along the colon by either the stoma or the rectum

Radiographic Features

Stage of Onset —The ulceration usually begins in the sigmoid and it is there that the first changes are visible

When filled with a barium enema the affected segment may show some hypertonicity and its contour may be rather shaggy

The same appearance is seen in the first stage of a thorium enema The mucosal pattern in the second stage that of collapse, is characteristic The plication of the mucosa is completely disordered There is no symmetry in the plicæ which take the form of an irregular enlarged and mottled network Gas inflation proves the colonic wall to be normally distensible The opaque contour line is interrupted and irregular and tiny ulcer craters may be detectable on occasion The mucosal surface seen *en face* may present irregular opaque droplets of the opaque medium

Developed Stage —As the process develops the radiological picture changes The ulcers are larger and tend to be confluent their margins undermined and the affected portion of the wall infiltrated and thickened

The barium enema method begins to reveal characteristic signs On observing fluoroscopically the enema running in the impression is gained of a rigid contracted tube Haustration is feeble or absent and the transit of the enema through the colon very rapid The absence of haustration produces the well known ribbon sign (Fig 193) The colon appears as a smooth ribbon shadow often if cicatrices have not developed remarkably uniform This appearance is due to the rigidity resulting from the infiltration of the submucous and muscular coats An ulcer crater seen in profile causes an irregularity on this smooth outline if its edges are undermined notches may be seen The undermined mucosa may result in a double contour in small sections of the colonic profile

With the thorium enema the *stage of filling* shows an appearance of the same type as above but the lesser degree of filling allows more irregularity of

the contour to appear to which undermined craters hypertonicity infiltration, and fibrosis may all contribute False diverticula may be present and be visible The *stage of collapse* is marked by a failure to collapse completely The bowel wall has lost its elasticity and the lumen is not emptied sufficiently to develop a satisfactory mucous pattern In those segments which do empty themselves the plicæ are scanty and ill developed The *stage of inflation* proves that the rigidity of the colonic wall is relative—the lumen is larger than in the first stage The contour here is very irregular and broken by spiky projections and, maybe false diverticula The intermarginal zone shows coarse irregular reticulum

HYPERPLASTIC AND SCLEROTIC STAGE —The barium enema shows very typical changes The rigid tube and ribbon shadows persist and there is a considerable diminution of the colonic lumen Irregular stenosed segments are clearly visible and haustration is completely absent If in addition to the hyperplastic fibrosis the mucosa develops polypoid granulomatous changes these will add a further irregularity to the contour

The filled stage of the thorium enema shows a similar appearance Collapse of the colon barely takes place and no *mucosal plicæ can be visualised* *In*flation causes slight dilatation of the less affected portions of the gut but is unable to distend the stenosed sclerosed portions The mucosal pattern *en face is a disorganised reticulum in which ulcer crater or diverticulum may make* itself visible

Fig 193 —Developed ulcerative colitis with absence of haustrations and rigid contour

COLITIS DUE TO SPECIFIC INFECTIONS

Those forms of ulcerative colitis resulting from infection with the entamœba histolytica lamblia trichomonas or the dysenteric bacillus show no radiological features to distinguish them one from another or from the non specific forms described above

The diagnosis rests securely on the results of bacteriological examination and thus established radiographic examination serves to indicate the degree of the pathological changes The earliest stages show the appearances of a mucous colitis the later those of an ulcerative colitis in its various stages

down to the contracted fibrotic stage It is said that if the amœbic form becomes chronic it shows in its late stages an especial tendency to fibrotic contracture of the gut

SYPHILITIC COLITIS

This condition is extremely rare and exhibits a preference for the sigmoid and rectum

The essential lesions are granulomatous formations and ulceration In general specific sigmoiditis may take one of two types—an infiltrated variety

FIG 134 Polypoid ulcerative colitis showing honeycomb pattern four hours after a meal

in which the submucosa is permeated and the sigmoid transformed into a rigid tube and a hypertrophic variety in which the wall of the gut is greatly thickened and nodular and the lumen irregularly narrowed The deciding diagnostic points are however not radiological but serological histological and therapeutic

ILEO-CÆCAL TUBERCULOSIS

Pathology—Hyperplastic tuberculosis of the bowel affects the cæcum in the majority of cases and may spread thence to the ascending colon and the last inch or two of the ileum The feature of the condition is the marked thickening of the cæcal wall and consequent narrowing of its lumen

The disease starts in the submucous coat with a diffuse round celled infiltration, followed by a considerable fibrous hyperplasia, both in and round the wall The mesocolon may be involved and, by *contraction, drag the* cæcum upwards The ileo cæcal and adjacent mesenteric glands are often *affected* Eventually *the lumen of the bowel becomes fibrosed and markedly* narrowed, with gradually increasing obstruction

In addition to the hyperplasia, ulceration of the mucosa may take place, and polypoid vegetations may grow into the lumen

Clinical Features —The disease is most commonly met with in patients between 20 and 40 years of age, and has an insidious onset There may or may not be a preceding involvement of the lungs In the early stages the patient may complain of little more than vague ill health, and a sense of discomfort in the right iliac fossa With the onset of ulceration, diarrhœa and *the passage of blood and mucus may occur As the disease progresses further*, a palpable mass becomes detectable in the right iliac fossa and signs of chronic ileal obstruction make their appearance

Radiographic Features —These depend on the stage of the disease In the early stages, before the onset of obstruction the abnormal appearances result from the rigidity and contraction of the cæcal walls *Stierlin* has described a sign which he believed to be pathognomonic of cæcal tuberculosis This consists of a gap in the barium shadow in the cæcum when the ileum, cæcum, and proximal colon are filled by a barium meal At, say, six hours after the ingestion of the meal, the ileum is filled down to the ileo cæcal valve, and also the ascending colon, the cæcum, on the other hand, remaining empty Although *in some cases this is a pure spastic phenomenon, it is sometimes due to spasm* and organic contracture combined The amount of deformity due to each factor can be determined by a barium enema, a method which delineates the degree and contour of the narrowed lumen with much greater certainty, and which should be used in every case that shows a suspicious appearance with the barium meal The type of filling defect with a barium enema depends on the macroscopic form of the disease present When hyperplasia predominates, the narrowing is more regular, and is of the kind seen in scirrhous carcinoma of the stomach When filled with the barium enema, the cæcum is frequently conical the apex downwards The margins of this cone may be fairly smooth or jagged and indented The presence of nodular masses projecting *into the lumen causes irregular "finger print" defects in addition to the* hyperplastic narrowing When the ileum is involved the barium meal may *show an irregularly narrowed portion contrasting with the normally* filled portion proximal to it Stierlin's sign is not exclusive to ileo cæcal tuberculosis Fig *162* shows a classical Stierlin's sign in a case of Crohn's disease

With the onset of chronic obstruction, the radiographic picture of ileal stasis is added to the picture This is shown only by the meal which should

therefore be used as a routine in addition to the enema in the investigation of these cases

The mucous pattern shown by the thorium flocculent enema may show features of importance in the diagnosis These vary according to the predominant pathological process in the case

In the ulcer hyperplastic form the affected cæcum shows in the collapsed stage of the thorium enema absence of the plicæ which have been destroyed by the disease or a few scattered and disorganised plicæ separated by areas

(a) (b)

Fig 13 Tuberculosis of the cæcum and ascending colon
(a) Seven hours after an opaque meal Shows no obstructive ileal stasis and Stierlin's sign
(b) The same shown by a barium enema

with no sign of plicæ Inflation of the colon fails to distend the cæcum to an extent depending on the degree of infiltration and rigidity of the wall of the gut Hyperplastic nodules may be seen in relief but as a rule the distension is insufficient to show these The colon distant from the actual lesion may show a reflex irritated state of the mucosa as described under the section on colitis viz increase in number and decrease in size of the plicæ their general arrangement remaining intact The ascending colon adjoining the affected cæcum may show a mixture of these states—areas of involvement by the specific process with adjacent areas of normal but reflexly irritated mucosa

In those cases in which the hyperplasia becomes polypoid the latter state

adds a typical feature to the local mucosal picture an irregular opaque network outlining rounded clear areas of varying sizes and shapes—the polypoid masses

In the fibrotic form the conical constriction is more marked when filled with the enema In the stage of collapse no plicæ are visible but the colon elsewhere is said not to show reactive changes Dilatation by air is impossible because of the rigid fibrosed cæcal wall

Differential Diagnosis —It is obvious from the above that cæcal tuberculosis presents a radiographic picture very similar to *carcinoma* so much so that they

Fig 196 —Multiple tuberculous stenoses in the colon.

are as a rule radiologically indistinguishable Calcified *ileo-cæcal glands* may be visible and suggest tubercle as the cause but with no certainty since they may represent merely a juvenile adenitis long since healed and may have no connection with the active cæcal lesion If the barium meal shows involvement of the ileum also a tuberculous lesion is indicated

Localised appendix abscess or *fibrotic sequelæ* from an old abscess may also cause so similar an appearance as to be indistinguishable in a barium enema but the thorium method shows a normal mucosa which serves to differentiate

them Unfortunately the thorium enema is often unsuccessful so far as the cæcum is concerned

As a general rule no confident radiological differentiation can be made between ileo cæcal tuberculosis and carcinoma, and the safe rule is to regard the condition as the more serious, unless clinical, serological and bacteriological evidence gives a lead Even if the condition is mistaken for carcinoma no great harm is done, since the tuberculous lesion is likely to come eventually to surgical interference

Actinomycosis of the ileo cæcal region is similarly indistinguishable radiologically.

ACTINOMYCOSIS OF THE COLON

This is a rare disease, and its radiographic appearances are as a rule indistinguishable from cancer

Querneau describes a case involving the descending colon, showing with a barium meal a constriction of the gut similar to that of a scirrhous carcinoma The absence of ulceration of the mucosa was noteworthy in this case

L P Good reports a series of sixty two cases of abdominal actinomycosis, and points out that the primary lesion in 77 per cent of them was the ileo cæcal lesion The majority start with the signs of acute appendicitis, and after appendicectomy a sinus persists and a thickened mass develops in the right iliac fossa from the brawny leathery infiltration of the surrounding tissues The ileum and cæcum are commonly involved in this infiltration Ileal stasis is prone to result and the contracted, deformed, fixed cæcum may be seen in a barium enema The filling defect is often indistinguishable from carcinoma or tubercle and the diagnosis is mycological As the disease progresses abscesses tend to develop in the lungs liver, kidneys and abdominal wall

CHAPTER XXII

COLONIC STASIS AND OBSTRUCTION

CONSTIPATION

CONSTIPATION or functional stasis in the large intestine is difficult to define on account of the marked variations which occur in normal individuals In some subjects the normal habit is two or three evacuations per diem *in the* great majority one per day but on the other hand one evacuation every two or three days may be consistent with normal health

Constipation is one of the commonest complaints of neurotic individuals and is often complained of even when it does not exist It is a commonplace that in such patients who regularly do e themselves with *aperients and* purgatives of all kinds the failure to obtain an evacuation on a single day at *once precipitates an array of symptoms* such as abdominal discomfort and distension actual pain nausea lassitude dizziness etc In many of these cases it is obvious that the symptoms are part of the neurosis and that they are produced not by the constipation but by the knowledge that the bowels have not acted Radiology may be of help in the management of these patients by demonstrating that there is no real stasis in the colon *that it is controlled* adequately by simple laxatives or that the stasis is rectal in site and therefore without serious constitutional effects

The chief value of radiology in the investigation of constipation is in differentiating functional stasis from the organic obstructive type This is discussed in the section on organic obstruction of the colon Three types of functional constipation are described according to the site of the delay cæcal colic and rectal

***Cæcal Stasis* —*This is rare* and is detected only by a barium meal examination The patient is unaware of the condition since daily evacuation takes place in the normal way and it is doubtful if it has any clinical significance The main length of the colon empties itself in normal time but the cæcum tends to retain barium Some writers have described it as one of the signs of chronic appendicitis but *this relationship is also very doubtful* *Barclay* suggests that it results from a defect in the mechanism of the mass movement of the colon He puts forward the view that if the *point d appui* of this peristaltic wave (in other words the initial constricting ring) is incomplete some *of the colonic contents are forced backwards into the cæcum and* pack it This appears to be the most reasonable *explanation*

Colic Constipation —This is the commonest type of constipation and results from a failure of the normal mass movement In some cases the

supposed delay is physiological and represents the normal colonic habit In others it is pathological and may be associated with various conditions such as the neuroses visceroptosis and mucous colitis Poisons such as lead nicotine and the opium group tend to abolish the reflex and so produce stasis Absence of residue in the diet is said to be a factor but if so it is not an important one in most cases

Radiographic Features —The stasis may take place anywhere in the colon proper and is most common in the transverse portion It is demonstrated clearly by a barium meal but in some cases the stasis as shown by the barium meal is less than with ordinary food The mass of the barium in the colon may excite a mass movement in a way that the normal contents do not do The experiments of *Alvarez* and *Freedlander* with glass beads with and without a barium meal confirm this slight accelerating effect of barium sulphate In the early stages of the barium meal examination the contrast medium may be disposed evenly in the transverse colon with deep regular haustrations but on succeeding days scybala are formed and the barium tends to be scattered in irregular masses especially in the distal portions This irregular distribution with intervening portions of empty gut and the absence of any colonic distension are important indications of the functional nature of the stasis In mild degrees of stasis most of the barium is evacuated in three days In severe degrees a week or more may elapse but it may be too uncomfortable for the patient to prolong the examination to the end in these cases A shorter examination gives the necessary information and the efficiency of the patient s usual aperient may then be usefully determined

Rectal Constipation (*syn* dyschesia or dyskezia) —This is a common variety and results from the loss of the defæcation reflex The commonest cause of this loss is neglect The patient gets into the habit may be in childhood of ignoring the daily call to stool and the reflex gradually disappears In addition to or in place of simple neglect there may be other causes Weakened abdominal and pelvic muscles from repeated pregnancies are said to make defæcation more difficult and act as contributory causes Inflamed piles fissure in ano and chronic inflammation of the adnexa make defæcation painful and tend to inhibit the reflex

Radiographic Features —The characteristic appearance with a barium meal is the collection day by day of an increasing mass of barium in the rectum until in a marked case the latter is dilated out to the size and shape seen in a normal barium enema examination If a moderate mass is seen on screen examination at the twenty fourth hour and the patient admits to no desire to go to stool the presence of dyskezia is probable A larger mass present on the following day confirms it

While constipation can be radiologically examined only by the barium meal it is so important not to overlook any organic colonic cause of the stasis that the meal should be followed by a barium enema in every case in which there is the least doubt

COLONIC OBSTRUCTION

Acute Obstruction of the Colon is too urgent a condition to allow of any lengthy *radiological investigation such as a barium enema*. Its presence and site can however be shown in many cases by a plain radiogram of the abdomen. This is a feasible procedure in an institution where a mobile ward equipment is available. The colon above the point of obstruction tends to become distended with gas and so is visible. In favourable cases this distension extends right down to the obstruction and locates the latter. This does not always obtain and care must be exercised in naming the exact site. Frequently the evidence has a negative rather than a positive value. Thus if the cæcum and transverse colon are uniformly distended it can be said that the obstruction is not above the splenic flexure, and a statement even as indefinite as this may give the surgeon the indication he requires in planning his incision. The presence of fluid levels in the bowel above the obstruction is often an important diagnostic feature. These may be shown in a lateral view taken with the patient supine.

FIG. 19.—Simple stenosis of the lower sigmoid causing obstruction to a barium enema.

Chronic Obstruction of the Colon.—Radiology as a rule gives definite evidence regarding the presence of this apart from the actual demonstration of the causative lesion. The barium meal and enema both give a characteristic picture in a well marked case.

THE BARIUM ENEMA should be used first, but prior to that a plain radiogram may give some preliminary indication if much gas is present. The presence of fluid levels should be noted.

With the barium enema, *the lower the obstruction the more definite are the signs*. The demonstration of obstruction by this method depends on the arrest of the barium column at the obstruction, and owing to the difficulty of ensuring a pressure of any moment in the cæcum and ascending colon, a halt in flow of the enema at that point is of less significance than in the descending or sigmoid portions. In a well marked chronic obstruction in the latter

regions, the sequence of events with a barium enema is as follows. The rectum fills out normally, and the barium passes in the usual way up to the point of obstruction. Continued administration of the enema then causes gradual distension of the already filled gut, without any advance of the head of the barium. A little of the enema may be forced through the obstruction, the amount depending on the severity of the latter. At the same time the patient experiences a gradually increasing distress and desire to evacuate. This culminates, if the administration is continued, in the escape of the enema past the rectal tube.

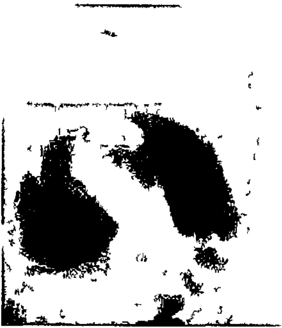


FIG. 138. Obstructive annular carcinoma of the left half of the transverse colon shown by a barium meal. The actual site of the growth is visible and proximal to the stricture the colon is dilated and shows a fluid level.

When these four features are present—arrest of the head of the enema, increasing distension below, increasing distress, and finally escape of the enema—a diagnosis of obstruction is justifiable and is usually correct, even if the actual obstructing lesion is not demonstrated. The lower the obstruction the more diagnostic are these signs. Fortunately in most cases the actual lesion is seen, such as the filling-defect of a carcinoma, the jagged contracture and barium-filled pockets of diverticulitis, or the sickle-shaped defect of extrinsic pressure, and these clinch the diagnosis.

It is often found in investigating those cases due to carcinoma that the obstruction to the enema is greater than to a barium meal. *Kerley* points out that the constriction tends to be funnel-shaped, with the narrow end below. There may therefore be a tendency to valve action in a direction retrograde to the normal flow.

THE BARIUM MEAL affords evidence as to the degree of stasis above the constriction and the degree of dilatation. It is safe to use it when the obstruction is high, e.g. the cæcum, since inspissation of the barium will not occur in that region. In obstruction low down care must be taken not to carry the examination over too long a period.

The appearances with a barium meal vary according to the site. In cæcal *obstruction the stasis is in the ileum; it has been described in that section.* When the obstruction is lower down, the first changes are in the colon. On following the barium in its progress along the colon, several changes are observed. The cæcum and ascending colon fill to a wide extent, but the onward progress is slow. The transverse colon, when reached, is seen to be considerably dilated, and the haustral contractions large, wide, and few in number. As the region of the obstruction is approached the head of the barium column loses its homogeneity, because of its admixture *with the transparent* colonic contents in front of it. This last feature is very characteristic

FIG. 199.—Obstructing carcinoma of the descending colon with marked gaseous distension of the colon above. (Barium enema supine.)

of obstruction, and is rarely, if ever, seen in functional colonic stasis. In organic obstruction the proximal colon gives the appearance of being "packed" with barium. In functional stasis the progress may be as slow, but it is obvious that the colonic lumen is poorly filled; portions of the gut between the static scybala are quite empty. Finally, in chronic obstruction the stenosed passage may be outlined, first with a mixture of barium and fæces, and later with homogeneous barium.

INTUSSUSCEPTION

This condition, the invagination of one portion of the gut into the lumen of the immediately distal part, is infrequently referred for X-ray investigation

In most cases the condition is urgent, the diagnosis obvious, and radiographic examination unnecessary If there is doubt as to the diagnosis and the condition permits a barium enema may demonstrate the lesion

The great majority of cases occur in young children and in them constitute a common type of acute intestinal obstruction It is a rare condition in adults and in them tends to be chronic and intermittent

Pathological Anatomy—An intussusception consists of three concentric tubes

(1) The entering tube

(2) The returning tube,

(3) The receiving tube or sheath

The first two constitute the intussusceptum and the last the intussuscipiens The junction of the entering and returning tube forms the apex of the intussusceptum and the junction of the returning tube and sheath is called the neck The mesentery is dragged in between the returning and receiving layers and as it becomes packed therein occludes its contained blood vessels and causes gangrene of the intussusceptum The drag of the mesentery on the mesial side of the intussusception causes the typical concavity of the tumour mass felt clinically

Classification—This is based on the portions of gut involved The common type is the entero colic involving both small and large intestine Rarer varieties are the enteric and the colic involving small and large intestines respectively The great majority of cases in children occur in the ileo cæcal region and therefore fall into the entero colic group Depending on the part forming the apex of the intussusceptum three types occur

(*a*) The *ileo-cæcal* in which the ileo-cæcal valve forms the apex This is much the commonest form

(*b*) The *ileo colic*, in which the ileum forms the apex and

(*c*) The *cæcal* in which the inverted cæcum forms the apex

The various types may be therefore tabulated as follows

(1) Enteric

(2) Entero colic (*a*) Ileo colic

(*b*) Ileo cæcal

(*c*) Cæcal

(3) Colic

Ladd and *Gross* have analysed a series of 372 cases in children The peak age incidence in these was 7 months and the percentage of types as follows

Ileo-cæcal and cæcal	74
Ileo-colic	16
Colic	2 0

In the great majority of these cases the diagnosis was clinically evident

...ases in which there was some doubt were submitted to

barium enema examination A correct diagnosis was made in sixteen of these In one an ileo cæcal intussusception no colonic abnormality was found

Radiographic Features —Although the diagnosis of acute intussusception is *usually evident clinically and requires no verification the X ray appearances*

(a) (b)

Fig 200 —Intussusception in a child aged 18 months

(a) The barium enema obstructed by the apex of the intussusceptum producing the characteristic cupping (b) After evacuation of the enema traces of barium have escaped into the shell or intussuscipiens

are so characteristic that a barium enema should be given if there is any real *doubt provided the patient s condition permits*

In a typical case there will be noted the following abnormalities (Figs 200 201)

(1) Obstruction to the Enema —The enema runs normally up the colon till it meets the apex of the intussusceptum at which point it is arrested

(2) Cupping of the Head of the Barium —The apex projecting into the arrested barium injection causes an indentation or cupping in the barium shadow at that point

(3) Filling of the Intussusception —The obstruction to the enema caused by the invagination is not usually absolute Gradually a thin incomplete cylindrical shell of barium spreads between the receiving and return

ing layers of the intussusception. Although theoretically a central streak of barium might escape along the lumen of the intussusceptum, actually œdema usually seems to prevent this.

(4) Localisation of the Tumour.—By radioscopic palpation, the tumour felt clinically can be shown to correspond to the barium shell.

(5) Residue after Evacuation.—Barium tends to remain entangled between the sheath and intussusceptum after the barium has been evacuated.

Several observers have noticed a spontaneous reduction of the intussusception during and apparently as a result of the pressure of a barium enema. This is a fortunate occurrence, and one which can be followed throughout its course fluoroscopically, but it is too uncertain to warrant the use of an opaque enema for that purpose.

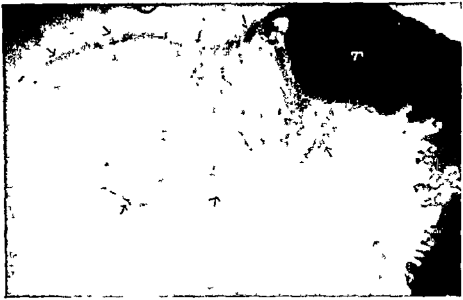
Indeed, time is so much the essence of the contract of safety in these cases that none should be wasted even on a diagnostic opaque enema, unless the doubt as to the diagnosis is real. If, however, a diagnostic opaque enema is decided upon, it is worth while attempting, by *gentle* abdominal massage and gentle fluid pressure by the gravity fed enema, to reduce the invagination. The two criteria of success in this manœuvre are the unfolding of the colonic reduplication seen by the filling of its lumen, and the escape of the enema into the ileum. Even if reduction is complete, narrowing of the colonic lumen will be evident from œdema of the colonic wall.

After fluoroscopic reduction the child must be kept under very strict observation in case the reduction is incomplete or the condition recurs.

VOLVULUS

The term "volvulus" is applied to the twisting of a segment of bowel on its mesenteric axis. The sigmoid colon is the portion involved in the great majority of cases—75 per cent according to *A. Mills*. This segment is particularly prone to volvulus because of the *sigma* shape of its mesentery. In the greater number of cases the condition constitutes an acute surgical emergency, being one of the most fatal forms of obstruction. Not only does the twist obstruct the bowel, but it also cuts off the blood supply and causes gangrene of the affected portion.

In a few rare cases the obstruction is incomplete and the vascular supply intact. In these cases of chronic volvulus radiological examination may be of help. The bowel up to the neck of the volvulus can be shown with a barium enema, and if any of the enema can escape through the neck, a sickle shaped shadow may be visible, representing the narrowed first twist of the distal limb of the volvulus. In addition, depending on the degree of obstruction, gaseous distension may be evident above. Obviously a barium meal might be a dangerous method of examination in these cases.



(a)

(b)

FIG 201 —(a) Intussusception showing obstruction to the opaque enema in the transverse colon, with coating of the sheath.
(b) The resected specimen

GALL-STONE IMPACTION

Gall stones of a size (1 inch or more in diameter) sufficient to cause obstruction by impaction in the small intestine are usually to some extent calcified and so visible in a radiogram Except in very rare cases the gall stone reaches the intestine by ulcerating its way through the gall bladder and adherent jejunum and it usually impacts in the lower ileum The larger it is the higher the impaction It may therefore be visible in the right iliac fossa in a plain radiogram taken to determine the site of the acute obstruction which is the usual sequela of impaction

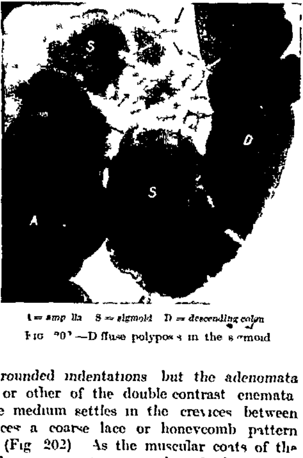
CHAPTER XXIII

TUMOURS OF THE COLON

BENIGN TUMOURS OF THE COLON

Solitary Tumours such as adenoma fibroma lipoma or myoma are rare They usually become pedunculated and project into the lumen of the bowel If large enough they may show a mobile central filling-defect with a barium enema but they may easily escape detection by this method They can be demonstrated with greater certainty by one of the double contrast methods, but even when one of those is used a negative result does not exclude them with certainty

Multiple adenomata (*syn polyposis of the colon*) may be present in large numbers and may cover a large portion of the colonic mucosa At first they are small flat and sessile but some may grow to the size of a cherry and become polypoid Clinically they give rise to intractable diarrhœa painful tenesmus and blood and mucus in the stool Ulceration and malignant degeneration are common *sequelæ*



A = ampulla S = sigmoid D = descending colon

Fig 202 —Diffuse polyposis in the sigmoid

Some indication of the condition may be seen in the contour of the barium enema picture *in the form of small rounded indentations* but the adenomata are best demonstrated by one or other of the double contrast enemata With these methods the opaque medium settles in the crevices between the tumour masses and produces a coarse lace or honeycomb pattern which is almost pathognomonic (Fig 202) As the muscular coats of the bowel are not involved the lumen is not narrowed and the normal haustration is present

CARCINOMA OF THE COLON

This is a common disease and one in which the help of the radiologist is sought as a routine. The sigmoidoscope is within its ambit the conclusive diagnostic method but radiology is the most accurate method for the colon above the reach of that instrument. The method of choice is the barium enema for reasons already enumerated.

Morbid Anatomy

From the radiological point of view it is the macroscopic varieties which are important.

The commonest type is the *adeno-carcinoma* originating in Lieberkuhn's glands. This may form a tumour mass projecting into the lumen, which commonly ulcerates sooner or later.

The *scirrhous* type tends to encircle the bowel and produce a stenosis. The contracture may involve a segment of the gut 2-3 inches in length or be limited to a very narrow zone—the "string" carcinoma. Frequently a *mixture of these macroscopic types* occurs, with projection of a tumour mass into the colonic lumen, scirrhous contracture of its wall, and an ulceration of the projecting tumour or the colonic wall. In the stenosing type the channel may be reduced to a crow-quill without acute obstruction supervening.

The bowel above the lesion is frequently dilated and hypertrophied.

Site

The pelvic colon is the commonest site of carcinoma, next the cæcum and ascending colon, then the transverse colon and splenic flexure, and lastly the hepatic flexure and descending colon.

Anschutz and *Korte* have reported the following site incidence in a series of 377 cases:

	Per cent
Sigmoid	43.8
Cæcum, ascending colon and hepatic flexure	3 6
Splenic flexure, descending colon	14.1
Transverse colon	[illegible]

Radiographic Features

The cardinal feature is the presence of a filling defect in the barium shadow. The other signs are the presence of colonic obstruction, fixation of the gut, enterospasm and disturbance of the colonic mucosal pattern.

THE FILLING DEFECT.—This may be of various types depending on the size, shape and type of the growth. A tumour which projects into the lumen produces a defect of the *finger-print* type similar to that produced by an encephaloid carcinoma of the stomach. The contour of the gut is almost invariably involved also because of the relatively small lumen. If only a central filling-defect is visible, fæcal accumulation or a polypus is much the

more probable explanation In the cæcum however the wider lumen may result in only a central defect being visible

In the majority of cases the filling defect takes the form of an irregular narrowing of the bowel The *napkin ring* defect is a very typical appearance In this the normal lumen is abruptly interrupted by a narrowed portion of 1–3 inches This narrowed portion is commonly slightly excentric due to the greater mass of the tumour at its point of origin Two features of this type of filling defect are its sharply defined and rather jagged or irregular outline and its constancy These distinguish it from a localised colospasm

When the annular scirrhous growth is limited to a very short segment of the bowel the type known as the *string* defect is produced as though a ligature had been tied round the colon Even in this localised defect the contours of the bowel where they dip down to the constriction give evidence of their involvement in the growth by their slight irregularity and by the constancy of that irregularity in a series of radiograms The constancy of these defects such an important point in their evaluation can be tested by superimposition of the radiograms Although perfect fusion is usually not obtained by this procedure the deformities will show the same geographical features

Graham Hodgson has drawn attention to a simple test for the constancy of a filling-defect—that of taking two exposures on one film at an interval of some few seconds The normal portion of the barium filled gut will show a double outline owing to peristaltic action the filling defect either carcinomatous or diverticulitic will not

Attention to one type of filling defect has been drawn by *Lockhart Mummery* It results when a sessile adeno carcinoma ulcerates in the centre When this is seen in profile there is a double encroachment of the colonic lumen since the edges of the crater are somewhat raised In contradistinction to this the papillomatous growth produces a rounded filling-defect

The Barium Enema is the method of choice for the demonstration of a carcinomatous filling defect Only by it can the whole of the large bowel be filled with certainty and even when filled certain coils tend to overlap and obscure each other *In the sigmoid* this is a common occurrence and a growth just above the rectosigmoidal junction may be completely hidden in a postero anterior view The right oblique view usually separates these two shadows *and should be used as a routine in all barium enema examinations* *Occasionally* the left oblique view is more effective because of the disposition of the sigmoid and if the former oblique fails to show a satisfactory separation of the coils observed fluoroscopically the other should be tried

At the splenic flexure a similar reduplication of the two limbs commonly occurs and this region presents the further difficulty that it is quite inaccessible to palpation Again the optimum degree of rotation must be determined by screen examination but as a rule the left oblique position is the best

The hepatic flexure is accessible to the palpating hand and a lesion there is

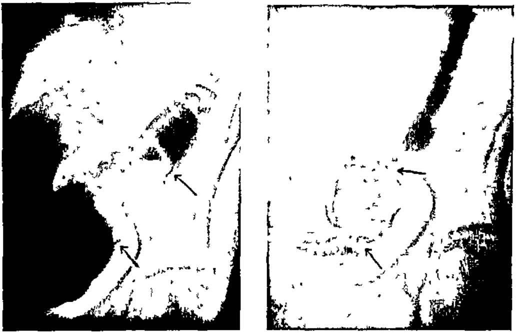
FIG. 203 — Annular carcinoma of the descending colon

FIG. 204 — Adenocarcinoma of the sigmoid showing "finger print" defects

FIG. 205 — Annular carcinoma of the sigmoid as seen in the second stage of a thorium three stage enema. The mucosal pattern is absent in the affected segment

more easily detected *The cæcum* often presents some difficulty, because of the size of its lumen and the difficulty of filling it uniformly. In spite of thorough preparation, the cæcum may contain a considerable quantity of fluid fæces, which dilutes the barium injection and causes a mottled or irregular shadow Careful fluoroscopic palpation should reveal the inconstancy of this appearance, and so its nature.

APPEARANCES WITH THE THORIUM FLOCCULENT ENEMA —In some cases a small *encephaloid carcinoma* is hidden by the overlaid shadow of a barium



(a) (b)

FIG 206 —Encephaloid carcinoma of the sigmoid
(a) Filling defect in the filled colon (b) Relief pattern of the tumour after evacuation of the enema

enema. *It is in such that the collapsed and inflated stages of a thorium enema* may be of value

The segment of the colon invaded by the tumour is rigid and does not *collapse readily. If by posture and massage it can be made to empty itself*, gas is apt, according to *Maingot*, to accumulate there. No plicæ are visible in an invaded area. In their place is an irregular disorganised areolar arrangement, *with clear areas and opacities corresponding to the tumour masses and* the interstices between.

Inflation with air shows the tumour mass in greater relief, an effect further enhanced by stereoscopic radiograms. The inflation also reveals the extent of narrowing of the bowel resulting from the neoplasm.

The *annular scirrhous carcinoma* of the colon is usually so evident with a barium enema that it is unnecessary to use the more complicated method, unless overlapping of coils obscures the lesion

The stenosed passage is of course clearly visible by the thorium method Collapse of the gut above the growth is usually prevented by the stenosis present That below the growth collapses normally and shows a normal mucosal pattern or one showing a reflex reactive state The stenosed passage shows no plicæ Air inflation shows up the stenosis with particular clarity

Fig 207 —Scirrhous carcinoma of the cæcum and ascending colon with ileal obstruction shown by a barium meal 7 hours after ingestion This patient had at the same time a scirrhous growth of the stomach

The double contrast enema either barium or thorium finds its particular sphere of usefulness in the doubtful case—one in which there is say an unexplained colonic hæmorrhage and in which an ordinary barium enema reveals no cause for the bleeding If by the more complicated procedure an occasional early carcinoma is discovered the method is well worth using even although many a blank is drawn Because of this possibility the method constitutes a definite advance in the early diagnosis of carcinoma coli

Differential Diagnosis of the Filling defect —Several other conditions may produce a gap in the barium shadow notably diverticulitis advanced ulcerative colitis cæcal tuberculosis actinomycosis simple tumours circumscribed appendix abscess colospasm fæcal concretions and gas Most of these are recognisable but difficulty may arise with cæcal tuberculosis and actinomycosis It may be quite impossible to differentiate radiographically between cancer tubercle and actinomycosis of the cæcum and the decision must then be arrived at on clinical evidence or biopsy

In the cæcum the site where the greatest difficulty arises in the differential diagnosis certain features may be of help

Encephaloid growths cause a ragged, worm-eaten filling defect Scirrhous growths produce a more regular contracture closely similar to cæcal tuberculosis, an appendix abscess causes a smooth regular one Ileal stasis may occur in all three in the following descending order of intensity carcinoma, abscess, tuberculosis

Any bubbles of gas that may be present during a barium enema tend to collect, in the supine position, at the apices of the colonic watersheds, namely the highest loop of the sigmoid and the middle of the transverse colon They are distinguishable from neoplastic central filling defect by the absence of any deformity of the wall of the gut, and by the fact that they are more transparent than the surrounding soft tissues Change in posture—e g to the prone—*completely alters their disposition*

Fig 208 —Carcinoma of the cæcum causing a filling defect thereof Laparotomy revealed secondary deposits in the liver

Fæcal accumulations and concretions may cause more difficulty, and re-examination may be necessary

The distinguishing features of diverticulitis, ulcerative colitis, pedunculated simple tumours, and colospasm are described under their respective sections

Obstructive Signs in Carcinoma of the Colon —Too often this feature is so marked when the patient first seeks advice, that radiology is not employed, the case goes straight to the theatre as an emergency Of the balance the majority show some evidence of stasis above the growth In many of these the degree of obstruction is sufficient to make the use of a barium meal unwise, but in other milder degrees the barium meal may be safe, and give useful evidence as to the degree of back pressure

The general radiographic signs of colonic obstruction are described elsewhere, and *it remains only to be said that in carcinomatous obstruction the actual obstructing lesion can be demonstrated by a barium enema in all but the most severe cases*—those bordering on the acute

FIXATION OF THE GROWTH —This as determined by radioscopic palpation during an enema examination is a late sign In the early stages the affected portion of the colon shows normal mobility, and only when the neoplasm has spread to surrounding structure does fixation take place Its chief significance is therefore as an indication of operability or the reverse

FIG 209 —Carcinoma of the descending colon with incipient perforation

ENTEROSPASM —In certain cases ulceration of the growth causes adjacent spasm of the circular fibres which modifies the filling-defect It is seen especially in the sigmoid and may cause a temporary obstruction to the enema Intermittent application of the normal gravity pressure of the enema usually causes a relaxation The practical importance of this spasm is in the difficulty it may cause in demonstrating the more serious underlying lesion

Perforation of a Carcinomatous Ulcer

This constitutes a surgical emergency and the only occasions on which this is demonstrable radiographically are when the perforation occurs accidentally during the course of a barium enema examination This mishap may take place without any undue enema pressure if the ulcer is already near the point of perforation and constitutes a warning against using too high a gravity head in the administration of the enema The fluoroscopic appearances are characteristic the barium is seen to pass along the colon normally to the point where perforation occurs and thence in a flood into the peritoneal cavity

The only thing that can be said in mitigation of this unhappy occurrence is that the inevitable perforation is discovered at the earliest possible moment !

SARCOMA OF THE COLON

This is a rare disease and is most frequently met with in young subjects It usually involves the cæcum It tends to infiltrate the bowel wall and convert it into a rigid tube obstruction is a late phenomenon It is impossible to differentiate it radiographically with any certainty from a carcinomatous growth

CHAPTER XXIV

DIVERTICULITIS OF THE COLON

CLINICAL FEATURES

Definition —This condition consists in the presence of small protrusions of the mucosa through the muscular coat and the formation thereby of small saccular pouches Inflammatory changes commonly supervene in and round the diverticula

Terminology —Although the term diverticulitis is commonly used to include all the stages that occur in this disease it is convenient to describe the pre inflammatory stage as one of diverticulosis and to restrict the term diverticulitis to those cases in which inflammation has occurred and which *consequently give rise to symptoms If the view of Spriggs is accepted to* those there may be added the pre diverticular stage

Ætiology —The *precise cause is unknown It is a disease of the later* decades of life few cases occur before the age of 40 and its incidence is progressively greater with increasing years In the writer s experience males are more commonly affected than women and the condition is much more common in private than in hospital practice A spastic condition is held by some authorities to be a factor in initiating the early mucosal herniation and the imperfect nature of the outer muscular coat of the colon doubtless makes it easier for the protrusion to occur

Spriggs found in 3 000 barium meal or enema examinations that 10 per cent showed evidence of diverticulosis and 2 3 per cent evidence of diverticulitis Associated cancer was found in only four cases This last is within the limits of coincidence The average age was 56 the ratio of men to women was 54 16 and one third of the patients were obese

PATHOLOGY

The protrusion commences as a tiny V shaped mucosal process which wherever it passes through the inner muscular coat enlarges into a flask or currant shaped saccule with a narrow neck The herniation always takes place along the edges of the tænia (at points where the blood vessels penetrate the muscular coat) and never through them The wall of the diverticulum is therefore formed of mucous submucous and peritoneal coats Sometimes the diverticulum penetrates an appendix epiploica and so acquires a fatty coat as well

The diverticula range in size from 1 or 2 mm to about 2 cm The majority

are about ½–1 cm in diameter They are generally held to be pulsion diverticula herniating through weak points in the bowel wall Their tendency to develop above a colonic stricture is quoted by *Lockhart Mummery* in support of this view

Site—Diverticula may occur anywhere in the cæcum and colon but by far the commonest site is in the iliac and pelvic portions The most frequent distribution is a considerable number in the sigmoid and a few scattered elsewhere Usually they become progressively fewer as the colon is traced upwards In a number of cases they are limited to the sigmoid and even when they are also present elsewhere the stage of the disease is more advanced in that segment the diverticula are more numerous larger and inflammatory changes if present more severe Occasionally a diverticulum may develop in the appendix According to *Lockhart Mummery* they do not tend to develop pathological changes in this situation This is a curious fact if true in view of the tendency to formation of concretions in the appendix itself

Inflammatory Changes—Sooner or later in the majority of cases the stage of diverticulitis is reached The changes are almost exclusively limited to the descending iliac and pelvic portions and especially to the latter The inflammatory stage is initiated by stasis in the diverticula Scybala tend to form in the pouches and if they become sufficiently inspissated they are retained and set up catarrhal changes in the same way that an appendix does if it contains a concretion

These early inflammatory attacks may subside without causing much structural change again as in catarrhal appendicitis but in time the submucosal coat becomes involved by the formation of minute intra mural abscesses The wall of the gut adjacent to the diverticula also shares in the process The peritoneum reacts to the irritation in the form of a plastic peritonitis In an established case it becomes thickened and the diverticula tend to become partly or completely submerged in the hyperplasia The same process causes a narrowing of the lumen of the gut In all but the advanced cases some of this narrowing seen radiographically is however due to spasm of the circular muscular coat and only part to organic stenosis The inflammatory hyperplasia accounts for the sausage shaped tumour which is frequently found on clinical examination Peritoneal adhesions commonly occur in the later stages resulting in fixation of the affected segment Perforation of a diverticulum or of an intra mural abscess may occur but because of the adhesions general peritoneal infection is not so common as in a perforated appendix The perforation may take place into the bladder or may result in a localised abscess

Stenosis of the colon commonly results when the stage of the sausage tumour is reached It may however occur from pericolonic adhesions or from a smooth intrinsic fibrotic stricture without hyperplasia In this last type the diverticula may be so compressed that they do not fill with a barium

enema and the narrowing may be mistaken for a scirrhous carcinoma This is the type most amenable to surgical excision

Lockhart Mummery has summarised the complications of diverticulitis as follows

(1) Tumour formation
(2) Abscess intra mural or pericolonic
(3) Colonic stricture
(4) Pericolonic adhesions
(5) Fistulæ especially vesico colic
(6) Carcinoma (he holds that diverticulitis predisposes to carcinoma, view at variance with those of *Spriggs*)
(7) General peritonitis
(8) Contracture of the mesosigmoid

RADIOGRAPHIC TECHNIQUE

The preparation of the patient by aperients and colonic lavage is important, the object being to empty the diverticula If there are clinical signs of active peridiverticulitis with the presence of a tumour mass it is unwise to use drastic purgation The diverticula are devoid of a muscle coat other than the muscularis mucosæ and it may be difficult to ensure their emptying by any preparation if their contents are inspissated This difficulty may be turned to advantage in estimating the severity of the condition since stasis in the diverticula is of clinical significance and the stasis can be demonstrated in a barium enema by the bubble or flask sign

Two methods of investigation are available—the barium meal and enema

Those who favour the *barium meal method* state that it fills and so outlines the diverticula with greater certainty than the barium enema and this is probably true The meal also indicates the degree of colonic stasis above the inflamed segment It has however several disadvantages (1) It may *aggravate a chronic obstruction* (2) It *usually fails to give an accurate* picture of the degree of the inflammatory change present and of the extent of the stenosis (3) If only a few diverticula are present it may be difficult to distinguish between them and intra lumenal scybala (4) The examination may last several days

The barium enema suffers from two theoretical objections—namely that the diverticula do not always fill so well and that the widely filled colonic lumen may mask some of the diverticula It is very rare however in the writer s experience that *none* of the diverticula are filled with a barium enema and failure to fill some of them is not of serious importance The masking can be minimised by taking radiograms in different planes The enema gives accurate information regarding the diverticulitic filling-defect shows a pre-diverticular spasm fills the majority of the diverticula and demonstrates diverticular

scybala Most of the advantages afforded by the meal method can be attained by examining the patient again twenty four hours after the enema examination

In the writer's opinion therefore the barium enema should be the method of choice in all cases of diverticulosis and diverticulitis and the meal reserved for cases in which the enema fails to elucidate the condition satisfactorily The enema should be administered in the ordinary way under fluoroscopic control and particular attention paid to the pelvic and iliac portions of the colon The diverticula if small may be difficult to see under the screen but any stenosed segment is usually visible and its mobility and tenderness to palpation should be tested Radiograms in the postero anterior and oblique views should be taken and one immediately after evacuation of the enema The examination is usually completed by a further radiogram twenty four hours later

If the barium meal is used the chief point of importance is that the examination should be continued day by day until the colon is clear of barium leaving only the barium filled diverticula This may take as long as a week and the demonstration may be rather academic for the trouble and expense involved

In cases of difficulty and particularly when it is desirable to decide a doubtful associated inflammatory change in a case of diverticulosis the double contrast barium air enema may be used or better still the thorium air three stage enema The particular advantage of the latter is the indication it gives of the number of diverticula and the state of the surrounding mucosa Early inflammatory changes can be detected by this method when the ordinary barium enema gives no indication of their existence

RADIOGRAPHIC FEATURES

The barium enema gives such a wealth of information about a case of diverticulitis compared with the barium meal that it is convenient to describe the enema appearances first and then to add any additional points demonstrable by the other method It is also convenient to describe the appearances stage by stage although in any one case several stages may be present contemporaneously in different sections of the colon

(1) The Pre diverticular Stage —This has been fully described by Spriggs It is shown by a barium enema only and consists of fine spastic notches either grouped on the summits of the haustral bulges or replacing those bulges (Fig 210 (*a*)) They are not uncommonly seen in early cases of diverticulosis in segments of the colon which are devoid of visible diverticula Their significance is the subject of some difference of opinion *Barclay* attaches little importance to the appearance *Spriggs* holds that it is a true pre diverticular stage spastic in nature and that the minute spikes represent the incipient herniation of the mucosa *Lockhart Mummery Graham Hodgson* and *Dukes* have shown by histological section that the tiny notches are

actually due to this beginning herniation. In his clinic, Spriggs has had the opportunity of observing some of these cases over a number of years and has noted the subsequent development of diverticula in segments of the colon which previously presented the spastic appearance. In the present stage of our knowledge the theory he holds provides the most reasonable explanation.

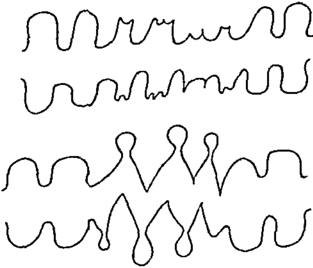


FIG 210.—Diagram of (a) Prediverticular spasm. (b) Developed diverticulitis with saw tooth effect and alternate notching.

The tendency to colonic spasm in diverticulitis is borne out by the difficulty that is frequently experienced in administering the barium enema in these cases. *In many cases the* sigmoid goes into spasm as soon as the rectum is filled, so much so that these cases acquire an unhappy reputation amongst the nursing staff of the X ray department!

FIG 211.—Diverticulosis.

(2) **Stage of Diverticulosis**.—This is characterised by the presence of barium filled diverticula, rounded opacities, varying in size from 1–2 mm. to 1–2 cm. and connected to the colonic lumen by a narrow neck (Fig 211). An apt *simile is a currant with its* stalk. Some of the diverticula may already be so completely filled with stercoliths that only the stalk fills with barium. More commonly a film of the opaque emulsion coats the surface of the contained scybalon and produces a characteristic ringed shadow like a bubble or

glass flask Frequently only the proximal half of the diverticulum is coated barium creeps half round it, and produces a characteristic crescentic or "wine glass" shadow

(3) **Stage of Diverticulitis** —It is not until this stage is reached that symptoms of any consequence arise, and its recognition is of some importance (Figs 212 214) It is characterised by changes in the lumen of the bowel rather than in the diverticula *The changes in the diverticula*, if any, are an increase in the

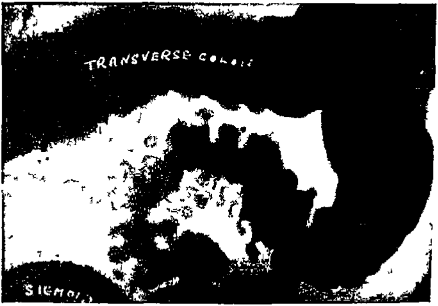


Fig 212 — Sigmoid diverticulitis shown by a barium enema The saw tooth notching is visible, indicating the inflammatory stage

number of flask shadows and the obliteration of some of them *The changes in the lumen* are quite distinctive in a developed case

(*a*) It is narrowed

(*b*) It presents a jagged or saw tooth contour, the apices of the teeth coinciding with diverticular necks A very characteristic variation of this appearance is an alternate notching with a diverticulum at the intervening peaks This gives the narrowed lumen a zigzag shape (Fig 210) In advanced cases the diverticula may be obliterated at the site of the inflammatory changes and the appearance may then resemble a carcinomatous filling defect Usually however, there is sufficient of the notched or saw tooth appearance to indicate the true nature of the condition even if no diverticula are visible elsewhere In this class of case the barium meal may be of real help in filling diverticula which are impervious to the enema

(*c*) An important feature of the inflammatory change is the constancy

Fig. 213—Sigmoid flexure. It is apparent after partial evacuation of the enema

Fig. 214. Barium-filled hepatic flexure and the left colon after the evacuation of an opaque enema

of the filling defect. Superimposition of a series of radiograms reveals an identical outline in each, allowing for variations in the distension of the lumen by the enema. In the well marked case even considerable distension fails to produce any change, since the walls are thickened, fibrosed, and inelastic. The spastic phenomena, on the other hand, are susceptible to some alteration from variations in distension and spastic tonus.

The double-exposure method described by *Graham Hodgson* is useful in demonstrating the constant inflammatory deformities of contour. It consists in making two light exposures on the same film at a few seconds' interval.

A = ampulla S = sigmoid Di = diverticulum C = carcinoma

FIG. 215.—Carcinoma and diverticulitis in same case

Slight alteration is seen in the normal bowel and none in the diverticulitic segment. Although not necessary in every case, it is of help in a case of doubtful inflammatory change.

Carcinoma may coexist with or supervene on a diverticulitis, and may then present a very difficult diagnostic problem (Fig. 215). Since the primary disease can produce a radiographic filling defect similar to a carcinomatous one (even to obliteration of the diverticular shadows), it is usually difficult and sometimes impossible to detect from the radiographic appearances the occurrence of this serious complication. The only safe course in a case of serious doubt is to act on the assumption that the worst has happened, and that a cancer has developed on top of the original lesion.

PERFORATION.—Perforation into the free peritoneal cavity is an acute surgical emergency, one which does not pay a visit to the X-ray department en route for the theatre. Perforation into the bladder is readily recognisable

A = ampulla. B = bladder filled with barium. Arrows = trickle of barium leading to the bladder.

FIG. 216.—Perforation of diverticulum into the bladder.

clinically, and can be demonstrated radiographically by the passage of a contrast medium from one viscus to the other (Fig. 216).

Appearances after a Barium Meal

The patient should be examined twenty-four hours after taking the meal, and on succeeding days as necessary.

This method shows the diverticula very well and demonstrates colonic stasis if present, but gives little or no information regarding inflammatory changes. In a well-marked case the diverticula are seen filled with barium *after the main lumen of the bowel is clear* and cannot be mistaken for anything else (Fig. 217). If only one or two opacities are present it may be difficult to determine whether they really are in diverticula. Barium in a diverticulum is extra-lumenal, and to prove that it is outside the colon proper the lumen of the latter must be fully outlined. Because of a tendency on the part of barium sulphate to cake, these diverticular shadows may remain for several days, a further point distinguishing them from scybala. Stasis of barium in them should not be regarded as evidence that similar stasis occurs with ordinary fæcal contents. A better index of real diverticular stasis is the flask shadow mentioned above.

Appearances after a Thorium Three-stage Enema

STAGE OF DIVERTICULOSIS.—The diverticula are the only abnormality seen. Their appearance in the *first stage* is the same as that in a barium enema. *After evacuation* the mucosal pattern is normal except for a corona of plicæ which occasionally surrounds the ostium of the diverticulum. *After inflation* the diverticula may present a variety of appearances:

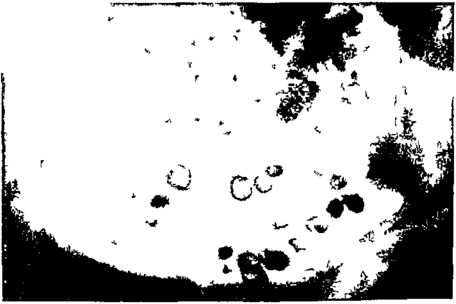


FIG. 1. Barium filled colonic diverticula 48 hours after an opaque meal showing the typical flask shadows.

(1) Thorium filled and seen in profile.

(2) Thorium filled and seen *en face*. They then appear as rounded opaque shadows in the intermarginal zone.

(3) Air filled and presenting an opaque flocculent lining. They then show a typical flask appearance.

(4) Half filled with air, half with thorium. They then appear as dark round opacities, unless examined with the subject erect, when they show a fluid level.

(5) Air filled and containing a concretion. Three zones are then visible: the central concretion, the clear air space round it, and the dark flocculent line on the surrounding mucosa.

The mucosa of the colon itself is normal in appearance in diverticulosis.

STAGE OF DIVERTICULITIS.—*The diverticula* appear exactly as above described, except that retention of concretions and scybala is much more common.

It is in the *intervening mucosa* that the changes indicative of the inflammatory process appear The mucosal pattern is difficult to produce since flocculation occurs with difficulty as a result of the associated colitis This also prevents complete and even collapse in the second stage of the examination

In the first degree of associated peridiverticulitis the pattern is a little distorted the plicæ fewer in number and rather thick As the inflammation increases in degree these changes increase until virtually no plicæ are visible at all

The third stage of the examination—inflation—reveals the rigidity and narrowing of the affected segment and the opaque marginal line is thick irregular and denticulated The intermarginal zone shows irregular opaque plaques in place of the normal crazing

The colon distant from the affected segment commonly shows changes—as a rule increase in number and thickening of the plicæ This is a reflex reaction in the muscularis mucosæ—the *etat irritatif* of *Maingot*

The bowel generally may show considerable spasticity again a reflex from an inflamed area of diverticulitis This spasticity in a region remote from the actual lesion may give an indication as to the degree of the inflammation and may often be seen to disappear as the acute focal inflammation subsides

RADIOGRAPHIC CONTROL OF TREATMENT IN DIVERTICULITIS

Medical Treatment —Medical treatment is in the early stages prophylactic *and is directed to keeping the stools semi liquid So long as stasis in the* diverticula is prevented the condition is innocuous The measures usually advised are a diet with little residue and sufficient doses of liquid paraffin or paraffin and agar agar to ensure that the stools shall never be of a firmer consistency than cream If paraffin does not agree mild aperients and salines are employed with the same object The efficacy of these measures may be tested quite simply by giving the patient a barium meal and taking radiograms *seven and twenty four hours after and subsequently as required* If the diverticula are clear as quickly as the main colonic lumen the measures taken are satisfactory *If not* a stricter regimen should be adopted

Surgical Treatment —In some advanced cases it is necessary to perform colo tomy usually in the transverse portion This relieves the condition entirely as long as the colostomy is open the patient is quite safe closure on the other hand is associated with some risk of recrudescence of the disease

In these cases after six to nine months the problem of closure of the colostomy must be decided By then all inflammation will have settled down *and further delay involves risk of too marked contracture of the bowel to allow* of closure

A barium enema is an essential preliminary to answering the following questions

(1) Is the inflamed segment too stenosed to allow closure of the colostomy without resection of the stricture?

(2) If resection is necessary to permit of closure is the bowel above and below the condemned segment sufficiently healthy and is there enough cloth' to allow a satisfactory anastomosis?

Plain closure of the stoma without preliminary re ection is possible only in a few case It is usually necessary first to resect the steno ed segment followed a month or so later by closure of the transverse colostomy and again a barium enema examination should be made of the sigmoid anastomosis before the stoma is closed

CHAPTER XXV

THE RECTUM AND ANUS

ANATOMY OF THE RECTUM

THE RECTUM consists of that portion of the alimentary canal from the recto-sigmoidal junction to the anus. It is variable in length, the average being 4–6 inches.

It begins to the left of the midline opposite the third sacral segment, and runs down in the midline in the hollow of the sacrum to a point 1 inch in front of the tip of the coccyx, where it joins the anal canal. When empty and collapsed it occupies the sagittal plane, and shows a curve with the concavity forwards similar to that of the sacrum. The middle portion of the rectum is very distensible, and is therefore sometimes called the ampulla. This degree of normal distensibility is well seen in a barium enema, or after a barium meal in a case of dyskezia. When distended, its lateral contours are indented by the valves of Houston.

The valves of Houston are three in number, and are radiologically important, since they cause indentations in the rectal shadow. They are crescentic folds of mucosa, each passing with a slight diagonal tilt round two thirds of the rectal circumference. They are inconstant in their position, but in general are arranged in a tier *en echelon*. *Lockhart Mummery* has described them as with their free edges overlapping like a photographic diaphragm. The uppermost is the most constant, and is situated anteriorly at the level of the peritoneal reflection. The lower two cause slight regular notches in the convex lateral contours of the distended rectum. The rectum, as it approaches the anus, curves gently forwards and finally turns abruptly downwards and backwards into that canal.

CARCINOMA OF THE RECTUM

It is possibly an overstatement to say that radiology should play no part in the examination of the rectum. Even if it is so, the statement serves to emphasise that fingerstalls are cheap, and that sigmoidoscopy is a simple procedure. If this seems to labour the obvious, the writer's excuse is that on several occasions he has been requested to make a barium enema examination for suspected carcinoma recti, before even a digital examination has been made. A barium enema examination may be necessary to determine the condition of the bowel beyond the reach of the sigmoidoscope, or the degree of dilatation above an already detected rectal growth, but to employ it to detect such a growth

itself is not only waste of an expensive method, but is also dangerous, since it may not demonstrate the lesion

With this caution it is permissible to consider what radiographic signs may be given by cancer of the rectum during the course of an opaque enema examination

The most constant change is diminution in size, the ampulla fails to dilate to its normal contour, in all but the smallest growths This is the result of the inelasticity of the infiltrated portion of the rectal wall (Fig 218)

A = ampulla R = rectum S = sigmoid

Fig 218 —Annular carcinoma of the rectum

If the growth is limited to the posterior wall this may be the only change in the postero anterior view The rectum then gives a "justo minor" appearance, as the filling defect on the posterior wall is masked by the barium in front of it The semi lateral view may bring the irregular defect into view, but not with certainty If the growth is on the lateral wall the filling-defect will stand out clearly unless masked by the sigmoid After evacuation of the enema it may be possible to see the irregular contours of the growth coated with barium particularly if some air be injected

SIMPLE STRICTURE OF THE RECTUM

This if severe, is an exception to the above rule Radiology may be an essential step in estimating the extent and degree of the narrowing, if neither finger nor proctoscope is admitted

There are four classes of simple stricture—congenital, traumatic, spastic, and inflammatory

The Congenital type commonly occurs at the muco-cutaneous junction of rectum and anal canal—the union of proctodeum and hindgut It may vary from complete atresia to slight narrowing

Traumatic Stricture is a type likely to require radiographic investigation and can result from a variety of causes, among which may be mentioned

wounds, cicatrisation after Whitehead's operation for piles, accidental injection of boiling or caustic enemata, and fibrosis following radium irradiation of carcinoma recti

SPASMODIC STRICTURE is a rare disturbance of the neuro muscular mechanism Although many authorities deny the existence of this condition, it has been authenticated by *Lockhart Mummery*

POST INFLAMMATORY FIBROUS STRICTURES form the largest group This is a common sequela of septic proctitis The exciting cause may be post operative sepsis septic proctitis following dystocia, old gonococcal infection, syphilis, dysentery, or bilharzia hæmatobia

It is not to be expected that X ray examination can do more than demon strate the presence of the stricture The cause must be determined by the anamnesis and clinical features of the case The X ray investigation is possible only if the stricture will admit a rubber catheter, but this it usually does If a catheter will not pass, acute obstruction is close upon the patient

The injection of the opaque solution should be closely watched under the screen, and gentle pressure only should be used, since the bowel above the stricture may be very dilated and thin In addition, the colon above the stricture should not be filled too full If distended, it may overlie and mask the stenosed rectum Antero posterior and both oblique radiograms should be taken to obtain as full a view of the narrowed passage as possible, and *stereoscopic views may be very helpful*

The success of the treatment of rectal stricture, be it by bougies, internal proctotomy, proctoplasty, or excision, may obviously also be checked by X ray *examination after an opaque injection*

FISTULA IN ANO

Fistula in ano is not ordinarily a condition in which radiographic investigation is used As a rule the surgeon is able to follow the course of the fistula without difficulty by other methods

Occasionally in cases in which there is a deep seated and complicated track, its ramifications may be demonstrated in stereograms after the injection of an opaque medium Either lipiodol or a sterile barium cream is a satisfactory medium The latter is to be preferred if there is difficulty in retaining *the medium in the fistula, since its viscosity can easily be increased*

If the fistula is blind, it is usually easy to fill the track completely, but if the track has an internal communication with the rectum this may not be possible A syringe with an olive tipped cannula should be used It may be possible to seal the mouth of the fistula with adhesive plaster, but often the ostium is too deeply placed in the natal cleft, and an attempt has to be made to occlude it by holding the olive of the syringe against it during the exposures A metal rectal bougie placed in the anal canal affords a means of orientating

the visualised track in the stereograms Stereoscopy is essential and a routine technique should include stereoscopic antero posterior views and also a lateral

CONGENITAL MALFORMATIONS

Of the congenital malformations of the rectum and anus, some are not susceptible to radiographic demonstration, since the alimentary canal ends blindly Theoretically, two could be demonstrated, although there appears to be no record of this having been done For the sake of completeness they might be mentioned

(1) *In the male* the rectum opening into the urethra just below the uterus masculinus by a narrow channel through the prostate

(2) *In the female* the rectum opening into the navicular fossa of the vulvar cleft behind the vaginal orifice

Both these result from a persistence of the original communication with the cloaca and are, according to *Clogg*, the commonest forms of rectal malformation

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PART TWO

BILIARY TRACT

BY

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PART TWO

BILIARY TRACT

CHAPTER XXVI

ANATOMY AND PHYSIOLOGY

THE SYMPTOMATOLOGY of biliary disease is complicated and often misleading Constitutional or local symptoms may predominate, and not infrequently the local symptoms are referred to a healthy viscus far removed from the biliary tract

The introduction of cholecystography has thrown considerable light on the ætiology course and symptomatology of biliary disease, but there is still much to be learnt and radiology is a most hopeful line of approach to outstanding problems A detailed knowledge of the anatomy and physiology of the biliary tract is essential if we are to carry out a radiological examination thoroughly and assess our findings accurately

ANATOMY OF THE EXTRAHEPATIC BILIARY TRACT

The normal gall bladder varies in shape size and position according to the habitus of the individual It also varies according to the stage of filling or contraction in which it is visualised and it alters considerably in position with changes in posture Roughly speaking we define three normal types—the spheroidal or hypersthenic type the ovoid or sthenic type, and the elongated or hyposthenic type The ovoid or sthenic is the type most often seen

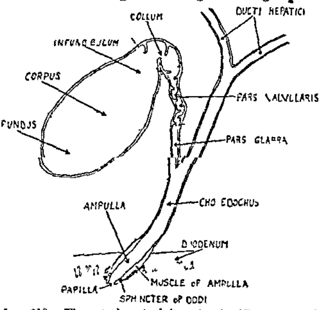


Fig 219 —The extrahepatic biliary tract (By courtesy of C Newman)

The normal gall bladder is composed of four parts viz a fundus a body, an infundibulum and a neck Smooth muscle fibres are found in the wall of the fundus and infundibulum but are almost completely absent in the body Conversely there is much elastic

tissue in the body and relatively little in the fundus and infundibulum The muscle fibres are arranged longitudinally and obliquely, but tend to be circular in the infundibulum This circular arrangement of the fibres is continued into the neck and valvular part of the cystic duct and there is strong radiological evidence in favour of a sphincter between the infundibulum and the neck

The neck of the gall bladder may lie in the same axis as the fundus but more often it turns inwards and downwards at a fairly sharp angle The cystic duct usually arises at an angle from the neck but this angle varies considerably according to the type of gall bladder and the stage of its contraction The proximal half of the cystic duct contains circular muscle fibres and the interior is thrown into folds known as Heister s valves The distal half of the cystic duct is similar to the hepatic and common bile ducts in that it contains few muscle fibres if any, and is simply a fibro elastic tube The common bile-duct runs downwards parallel to the spine, and usually passes through the pancreas before entering the duodenum obliquely at the papilla of Vater The volume of the normal gall bladder is about 50 c c but no limits can be fixed for its length and width

RADIOLOGICAL APPEARANCES OF THE VISUALISED GALL-BLADDER

The Ovoid or Sthenic Gall-bladder

(A) The Prone Position —(The appearance of the contracting gall bladder and bile ducts as described below can be noted only if the technique of serial radiographs immediately after a fatty meal is followed By the ordinary haphazard technique the ducts are rarely visualised) The gall bladder is ovoid or pear shaped about 9 to 10 cm long and about 3 to 4 cm wide Its long axis is parallel to the spine and at right angles to the eleventh and twelfth ribs The liver margin seen as an oblique line running downwards and out wards usually cuts across the gall bladder shadow at the level of the body This corresponds with the usual anatomical description the fundus of the gall bladder being free and completely surrounded by peritoneum and the body, infundibulum and neck being fixed in the hepatic fossa by connective tissue The gall bladder lies well forward of the kidney but radiologically the two shadows are superimposed In most cases the gall bladder is superimposed on the upper pole of the kidney but it may be superimposed on the renal pelvis or it may lie medial or peripheral to the kidney shadow Anatomically of course there is no relationship between the gall bladder and the right kidney, and the position and range of movement of both organs may vary considerably in the one individual The radiological relationship is intimate and of much importance because of the possibility of the shadows of biliary calculi being superimposed on the renal shadow and vice versa

If a barium meal is given it will be found that the fundus of the gall bladder is usually in apposition with the duodenal cap which is lying immediately

behind the fundus In some cases the gall bladder lies well to the right of the duodenal cap and in other cases it lies to the left of the cap and may be in contact with the pyloric part of the stomach

In about 2 per cent of normal individuals part of the gall bladder shadow is superimposed on the shadow of the second and third lumbar vertebra

(B) THE ERECT POSITION —Both liver and gall bladder are about ½ to 1 inch lower and lie below *the shadow of the twelfth rib* Their relative relationship is unaltered but if the gall bladder has been lying partly over the spine in the prone position it tends to fall away from it in the erect position In the erect position also the gall bladder shadow lies more to the right *of the renal shadow* The relationship with the duodenum is unaltered

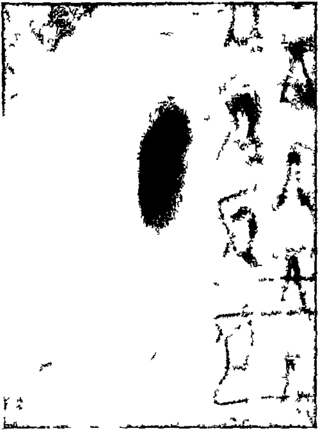


FIG. 0 The normal oval gall bladder as seen in the prone position

(C) IN THE SUPINE POSITION the liver and gall bladder fall back and upwards The long axis of the *gall bladder becomes oblique instead of perpendicular* and the fundus may lie completely behind the lower liver margin The gall bladder lies well away from the spine and its shadow is above or barely touches the shadow *of the upper pole of the right* kidney The gall bladder *duodenal relationship is not* altered In the supine position the pear shape is lost and the upper part of the gall bladder *the infundibulum is rounded and almost as wide as the fundus Occasionally in this position a slight or deep indentation may be seen in the* medial wall of the gall bladder This indentation represents the point of division between the body and infundibulum and it should not be mistaken for spasm

The neck of the gall bladder the cystic duct and the common bile-duct can be visualised only during the phase of active movement following a fatty meal In most cases a sharp indentation on either side separates the neck from the

infundibulum and at certain stages the neck may appear to be completely separate from the infundibulum this is fairly conclusive evidence that there is a strong sphincter between the neck and the infundibulum The neck itself may be shaped like the pointed end of a pencil and run straight upwards but more often it curves inwards and has been aptly described as resembling a bird s beak

The cystic duct usually leaves the neck to curve gently upwards and inwards for about ½ to 1 inch it then forms a complete semicircle and joins the common bile duct but the point of junction cannot be visualised Occasionally the cystic duct leaves the neck at right angles and in some cases the neck is so bent over on the infundibulum that the cystic duct appears to be leaving the infundibulum at right angles This appearance is very unusual but should not be mistaken for pathology (adhesions) The proximal half of the cystic duct containing muscle fibres and Heister s valves has a curious appearance due to the mixture of bile and mucus Small round globules of concentrated bile appear to be lying between the mucosal folds and this results in a rosary bead appearance This occurs in 75 per cent of cases and has occasionally been misinterpreted as stones in the cystic duct

The distal half of the cystic duct and the common bile-duct are seen as a smooth narrow tube with no irregularities of outline at any part the shadow of the bile in these parts is only about half the density of the shadow in the gall bladder and in the muscular part of the cystic duct The lower end of the common bile duct usually fades away into the spinal shadow and its point of entry into the pancreas cannot be seen

The Spheroidal or Hypersthenic Gall bladder

In stocky or short obese individuals and in most children the gall bladder tends to be more rounded and to be fixed more completely in the hepatic fossa In some cases the whole of the gall bladder is actually embedded in hepatic tissue It is then seen radiologically as a completely round opacity It follows that the mobility of the hypersthenic gall bladder is limited and its range of movement is dependent on the range of movement of the liver which is slight The hypersthenic gall bladder is situated relatively high and usually lies under the tenth or eleventh rib It is situated well to the left of the spine and well above the right kidney shadow Rarely as described by *Nemours Auguste* a hypersthenic gall bladder is actually superimposed on the spinal shadow In some cases the hypersthenic gall bladder has the ovoid shape of the sthenic type its long axis is then parallel to the lower margin of the liver and is almost at right angles to the shadow of the spine

The neck and ducts are more difficult to visualise in the hypersthenic type The neck is only occasionally seen and may appear to be the most dependent part of the gall bladder In most cases of this type there is no visible differentiation between the neck and infundibulum and the cystic duct seems to arise directly from the lowest part of the gall bladder

FIG. 221.—A normal ovoid gall bladder during the phase of active contraction. The cystic and common ducts are clearly visible: note how the coiled cystic duct tends to unfold.

113 A . . . gall bladder . . . Note the . . . appearance of the cystic duct. The appearance is less obvious . . .

The Long or Hyposthenic Gall-bladder

This type occurs in tall slender individuals and is characterised by a very wide range of movement The fundus and body are completely free and covered by peritoneum and the neck and infundibulum are attached to the liver by lax connective tissue In the prone and erect positions the gall *bladder is seen to be parallel to the* spine and in very many cases the whole of the shadow is superimposed *on the spinal shadow and may thus* be overlooked The fundus of the gall bladder may be as low as the level of the fifth lumbar vertebra in the prone position and may be level with or lower than the lower pole of *the right kidney One gets the im*pression in these cases that the gall bladder is ptosed and inefficient This is invariably an erroneous impression for if the examination is *properly completed and the gall* bladder observed in its active phase it will be found to contract and evacuate its contents normally The position of the gall bladder has nothing at all to do with its tone and there is no reliable record of a pathological ptosis of the gall bladder The neck and ducts are easily visualised in the hyposthenic gall bladder and are similar in position and appearance to those seen in the sthenic type There are of course many intermediate types between the three just described and the above classification should be taken only as a rough guide

FIG 3 The normal sphero tal or hypersthenic gall bladder

THE FUNCTION OF THE GALL-BLADDER

The liver is constantly secreting a thin watery bile which flows into the bile ducts and in the ducts is diluted by the addition of mucus This bile enters the gall bladder by flowing up the cystic duct provided the sphincter of Oddi is closed (*Newman*) The gall bladder concentrates this bile and when the pressure in the gall bladder falls below that in the bile ducts more watery bile runs in This process continues until the gall bladder is full of concen*trated bile According to Newman the sphincter of Oddi then relaxes and* liver bile drips steadily into the duodenum

The concentration of the bile in the gall bladder is carried out chiefly by

absorption of water Bilirubin is concentrated about twenty times, and cholesterol, bile salts, and calcium about five to ten times Calcium is excreted into the bile by the liver and partly absorbed and partly concentrated by the gall-bladder. It is now generally agreed that the gall bladder does not secrete cholesterol

This process of concentration can, to a certain extent, be confirmed and studied by cholecystography An hour or two after injection of sodium tetraiodophenolphthalein, a faint gall bladder shadow can be seen , from two to six hours after the injection the intensity of the shadow increases, but the size of the gall bladder diminishes It follows, from these observations that at different times the gall bladder contains bile of different specific gravities, one layer, so to speak, floating on top of another This theory explains the increased density of the shadow when the gall bladder has partially evacuated its contents after a fatty meal During the evacuation the bile of low specific gravity and gall bladder mucus are expelled first and the bile of highest specific gravity remains behind Whether the theory of multiple layers of bile and mucus is correct or not, particular attention should be paid to the question of different densities in the one gall bladder There are an increasing number of reports of floating gall stones i e small stones floating on top of concentrated bile, and it seems likely that with routine hospital technique these stones are being overlooked and the gall bladders passed as normal

The Mechanism of Emptying of the Gall-bladder

There is still considerable disagreement as to the exact method by which the bile leaves the gall bladder, and it has even been suggested that the bile was reabsorbed in the gall bladder and that Heister s valves were Nature s device to prevent the bile flowing back from the gall bladder into the cystic duct

It has been clearly established by *Westphal* and others that the vagus is the motor nerve of the gall bladder—light vagus stimulation causing the gall bladder to contract and the sphincter of Oddi to relax with simultaneous peristalsis of the ampulla and a flow of bile into the duodenum Strong vagus stimulation causes spasm of the gall bladder and ampulla and cessation of flow Sympathetic stimulation causes the gall bladder and ampulla to relax, with simultaneous contraction of the sphincter of Oddi and no flow As *Newman* points out, there is obviously a reciprocal innervation There is a humoral mechanism in addition to the nervous mechanism, the normal gall bladder reacting at once to injections of cholecystokinin, a substance which is produced by the action of acid on the mucosa of the duodenum and jejunum There is probably some cholecystokinin formed also in the stomach

The normal physiological stimulus to the evacuation of the contents of the gall bladder is the presence of fat in the stomach and duodenum There is a slight psychic reflex, taste and smell causing the gall bladder to alter its resting position and adopt what we shall refer to as the "preparatory position" Taste and smell, however, will not cause the gall bladder to contract *Nemours-*

Auguste has shown that this 'bucco vesical reflex' can be stimulated repeatedly without any evacuation of the biliary contents The same author has shown by mixing his fats with barium that the gall bladder in many normal cases begins to evacuate before the pylorus has opened i e before any fat has touched the duodenal walls

In studying the gall bladder radiologically we should see it in three phases

(1) *The resting phase* with the gall bladder flaccid and concentrated bile in the fundus and body

(2) *The preparatory phase* which can be excited by smell or taste or observed immediately after ingestion of the fatty meal In this phase the gall bladder, so to speak pulls itself together It alters its shape so that concentrated bile appears to be evenly distributed in the whole of it and the infundibulum and neck are visible It alters its position at the same time the general tendency being to move upwards and outwards The range of movement of the gall bladder in the preparatory phase varies of course with the type of gall bladder In the hyposthenic gall bladder a considerable shift takes place while in the hypersthenic type little or no alteration in position occurs

(3) *The phase* of *contraction* is observed after ingestion of a fatty meal at intervals varying in the normal from five to thirty minutes In the contraction phase the gall bladder is in the same position as the preparatory phase but its volume is smaller and concentrated bile is visible in the cystic and common ducts The normal times for complete evacuation of the gall bladder *have not yet been established Boyden has shown that the gall bladder empties more rapidly in women than in men and it is probable that there is quicker evacuation in children than in adults*

There is no doubt whatever that the gall bladder empties its contents by muscular contraction although the nature of these contractions must be totally different from those which occur in the gastro intestinal tract True peristalsis has never been observed and there are only one or two records of a wavy outline of the gall bladder in any way suggestive of peristalsis It is possible that an overdistended gall bladder may empty by elastic recoil but serial radiograms of the normal gall bladder during the contraction phase do not suggest that elastic recoil plays any part in the average case In some normal cases the gall bladder certainly rotates from side to side the author having observed the neck first pointing to the periphery and later pointing to the spine Both the neck and the cystic duct tend to straighten themselves out as the bile is forced into them It has been proved *that the normal gall bladder cannot be emptied by voluntary movements respiration nor duodenal peristalsis* Radiological observations have *also shown that vomiting does not cause it to contract* In two patients one with hyperthyroidism and one with hypertension the author observed the gall bladder contracting under pressure from a compressor but although there was no organic biliary disease in either patient, their general nervous instability was such that none of their viscera could be considered perfectly normal

CHAPTER XXVII

TECHNIQUE FOR X-RAY EXAMINATION OF THE BILIARY TRACT

PRELIMINARY PREPARATION

THE PATIENT must be adequately prepared by suitable aperients or enemata. Faeces and gas in the intestines can obscure the gall bladder completely or produce shadows simulating gall stones. Drastic aperients, such as castor oil and magnesium sulphate, cannot be recommended, as their action may irritate both the gastro-intestinal and biliary tracts for some days. Cascara is very suitable, as its action is mild and it does not tend to excite gas formation. In patients with obstinate constipation an enema is necessary, and this should be given at least 24 hours before the X-ray examination. Persistent gas formation, despite the effect of aperients and enemata, may cause great difficulty both in technique and interpretation. Many drugs have been used in an effort to expel intestinal gas, and the most effective of these is a substance known as pitressin. This substance is administered subcutaneously, 0.5 c.c. being injected from one to two hours before the X-ray examination. The dose can be repeated without any harmful effects in half an hour. Pitressin is eminently suitable in difficult gall bladder cases, as it does not cause the gall bladder to contract.

ROUTINE OF EXAMINATION

In all cases a preliminary radiogram on a 15 × 12 film should be made. This film, taken in the prone position, should include the domes of the diaphragm and the crests of the ilia. It should show the lower liver margin, the kidney shadows and the edge of the psoas muscles. A Potter-Bucky diaphragm is essential to ensure good detail, and the finer the grid the better the results. The Lysholm stationary grid is not very suitable, because the grid lines may obscure important detail. The most important feature in the technique is speed, and everything else should be subordinated to this. The slightest respiratory movement may be sufficient to cause enough blurring to conceal gall stones. The patient should be made as comfortable as possible and the exposure made at the end of expiration. An ideal speed, and one well within the limits of most modern apparatus, is two-fifths to one-half a second. The author uses this speed with the following factors: 90 Ma., 75–80 K.V., 90 cms. tube-film distance, Synchronised moving grid.

If the preliminary radiogram shows indisputable evidence of gall stones, it may not be necessary to carry the examination farther, but generally speaking it is a wise procedure to make a thorough examination by cholecystography,

as this may reveal unsuspected pathology in the ducts When the gall bladder has been made visible by sodium tetraiodophenolphthalein films are taken with the technique described above In a fair percentage of cases the *first picture will show some part of the shadow overlapping the spinal shadow* Using a ball of cotton wool as a compressor it is easy to displace the gall bladder away from the spine—this manœuvre will not cause the gall bladder to contract and the shadow can be adequately studied on this second picture *A third picture should be taken in the erect position with light compression* With modern methods of cholecystography and a good fluoroscopic screen it is not difficult to visualise the gall bladder on the screen when it has already been located on the prone pictures Only light compression should be applied *as the object of this method is to reveal floating stones and strong compression* may force such stones into the concentrated bile at the fundus When these pictures have been taken the patient is given a fatty meal consisting of two or three eggs beaten up with milk *Gutmann* and *Nemours Auguste* add some barium sulphate to this meal and simultaneously with the gall bladder study the gastric and duodenal mucosa A picture is taken in the prone position immediately this meal is ingested and usually shows the gall bladder to have changed from the resting to the preparatory phase Five to ten minutes after ingestion of the meal two further pictures are taken in the prone position one central and one slightly oblique with the right side of the body rotated about 15 to 20 degrees away from the table i e to the left The cotton wool com *pressor is used for these and it is also helpful to tilt the patient head down* wards about 10 to 15 degrees In 80 per cent of cases the cystic and common ducts will be visible on these pictures If not similar pictures are taken twenty and thirty minutes after the fatty meal until the ducts have been visualised Subsequent pictures are taken an hour after the fatty meal and these usually show the gall bladder to be contracted to one third or one fourth of its original size

This technique may seem too elaborate and expensive but it is the only one by which the biliary tract can be thoroughly investigated and as will be shown later it throws much light on those obscure cases of biliary dyskinesia where there is an apparently normal gall bladder shadow associated with classical *clinical symptoms of gall bladder distension*

CHOLECYSTOGRAPHY

It was long known by physiologists that the halogens were excreted almost entirely by the liver in the bile and tetrachlorphenolphthalein was frequently used as a test of liver function *Graham* and *Cole* in 1924 applied this know ledge to radiology, and attempted to visualise the gall bladder *in vivo* by *substituting the heavier bromine molecule for the chlorine one* Their results were successful and in a very short period the still heavier iodine molecule was substituted for the bromine the iodine compound giving a better shadow with

a smaller dose The substance in common use to day is the acid sodium salt of tetraiodophenolphthalein It deteriorates rapidly on exposure to light and should be kept in opaque bottles The drug should be freshly prepared for intravenous injection The drug can be administered intravenously or orally, and although most workers now employ the oral method as being simpler and less dangerous than the intravenous method there are many cases in which the intravenous method is preferable If an intravenous injection was an absolutely harmless procedure it would obviously be the method of choice as a measured quantity of dye is injected into the blood-stream and it can be excreted only through the biliary tract Using the oral method there is always the possibility that the dye will be unabsorbed in the intestine or that the phenolphthalein will excite diarrhœa with rapid excretion of much of the iodine through the bowel There is a group of cases in which the concentration of dye in the gall bladder is poor and only a faint radiological shadow is obtained The interpretation of faint shadows is much more reliable with the intravenous than with the oral method

Technique for the Intravenous Method

The patient on the evening before the injection has a liberal dinner, including fats The injection is given early the following morning weak tea with sugar but without milk being allowed for breakfast The dye which should be prepared the evening before is warmed to body temperature and injected slowly Some workers inject ½ c c of 1 in 1 000 adrenalin subcutaneously before the intravenous injection but this is unnecessary and indeed in some cases may produce unpleasant sensations of nausea and fainting The syringes used for the dye should be thoroughly cleaned in sterile water particular care being taken that there is no oily or greasy substance on the walls For an average individual 4 grms of sodium tetraiodophenolphthalein dissolved in 40 c c of distilled water are used For thin individuals and children half this quantity is used As the dye is blue black in colour it is almost impossible to see blood flow back into the syringe and it is usually easier to place the needle in the vein and then attach the syringe when the needle is safely in position The dye should be injected very slowly a safe rate being 4 c c per minute There should be no pain during the injection and the patient should be kept under observation for half an hour afterwards After this period he can carry on with his usual work The first picture is taken four hours and the second picture eight hours after the injection The maximum concentration is usually at eight hours and at this time the examination is completed by observing the effects of the fatty meal

Contraindications to the intravenous method are advanced cardiac and pulmonary disease asthenia or cachexia and severe jaundice The dangers of intravenous cholecystography are greatly exaggerated *Fried* and *Whitaker* have shown experimentally that the liver may be more than half fatty

degenerated and yet excrete the dye normally without any trouble. Accidents following the injection may be due to one of three causes (1) An impure solution has been used (2) An excessive dose has been injected There have been two fatal accidents following injection of 5 5 grms and one following the ingestion of 5 grms In these three cases however autopsy showed extensive liver disease (3) The dye has been injected too quickly Too rapid injection is much the commonest cause of accidents In some people a curious and unexplained train of symptoms follows the rapid injection into the blood stream of any substance of high atomic weight Half to one hour after injection the patient complains of cold and shivering and there is marked trembling of the limbs In severe cases there is pain behind the eyes and pains in the bones Vomiting and fainting can also occur and in very bad cases the patient may collapse into a kind of coma Many workers have shown that there is a rapid fall in blood pressure immediately after the injection this might cause collapse in a patient with heart disease but is unlikely to be responsible for the symptoms of pain and trembling of the limbs *Zappala* has shown that following injection of tetraiodophenolphthalein there is a hypoglycæmia after half an hour a hyperglycæmia after two hours and then a gradual return to the normal values in six hours Hypoglycæmia is a very likely cause of the symptoms just described and many workers use glucose along with the dye to prevent the onset of such symptoms In most cases the injection of ½ c c of adrenalin gives prompt relief but *provided that the injection is given slowly* there is no need to use either glucose or adrenalin as a preliminary prophylactic

There appears to be a general impression that leakage of the dye from the vein into the soft tissues is a serious incident This is not so and I have observed many cases where such leakage had occurred and no untoward effects other than temporary stiffness of the arm ensued Of course infection is always liable to occur if the dye or the instruments have not been sterilised In rare cases a severe non bacterial cellulitis or a mild phlebitis may occur

Rapid Cholecystography

Many workers have attempted to combine the sodium tetraiodophenol phthalein with some other substance which is rapidly excreted through the liver thereby obtaining more rapid visualisation of the gall bladder The method which has attained most prominence is that described by *Antonucci* It was early recognised that during either oral or intravenous cholecystography in diabetics the shadow of the gall bladder appeared much sooner than in normal individuals *Antonucci's* technique is based on this observation The patient has a diet poor in carbohydrates for three or four days before the injection The injection is made fasting under the conditions already described Ten minutes before the injection of the opaque salt 125 c c of a 40 per cent solution of glucose are injected Ten minutes after the injection of the opaque salt 25 units of insulin are injected The gall bladder can be faintly seen half

an hour later and the maximum concentration is obtained about two hours later The contractions of the gall bladder and the visualisation of the ducts are then obtained by the usual fatty meal The physiological basis of this technique is not properly understood it is thought that the tetraiodophenol phthalein is combined in some manner with the glucose and that the combination is more readily excreted through the liver than the opaque salt by itself It may be however that in hyperglycæmia the liver is stimulated and more rapidly eliminates the opaque salt The gall bladder filled by this rapid method is larger than the gall bladder filled by the usual method and moreover the concentration with *Antonucci s* technique is not very good It is doubtful if any material advantage is gained by *Antonucci s* technique and certainly none which outweighs the disadvantages of injecting three different substances at very short intervals

The Oral Methods of Cholecystography

If sodium tetraiodophenolphthalein is ingested in a pure form nausea and vomiting usually follow in a short period of time This is due to the salt mixing with the gastric secretion and forming phthallic acid which is a distinct gastric irritant In the early days of oral cholecystography the salt was usually administered in gelatine or keratin capsules which it was hoped would not be digested until they had left the stomach In many cases however the capsules were not dissolved at all and were excreted intact with the fæces The manufacturers have largely overcome this difficulty and the dye is now made up in a fairly palatable form with the phthallic acid already precipitated About 25 per cent of patients complain of nausea after ingestion of the dye and of these about 5 per cent actually vomit If the vomiting occurs within one hour of ingestion the test is invalid as too much of the dye is lost If the vomiting occurs within two hours of ingestion the test is usually valid as in this time sufficient dye has passed over the pylorus to be absorbed in the small intestine Some workers give various sedative drugs such as Dover s powder to prevent vomiting but the administration of such substances is to be deprecated In the present state of our knowledge of the physiology of the biliary tract it is impossible to predict the effect of many such drugs They may cause delay in filling or emptying or poor concentration

Single dose Oral Cholecystography

The following simple preparation is the only one necessary and is successful in the vast majority of cases Two days before the examination the patient takes a mild aperient cascara for preference The day before the examination the patient has a meal containing fats and eggs for lunch and for dinner at 7 p m has a fat free meal Many English workers do not consider complete fat restriction essential For dinner dry toast baked potatoes vegetable soups and all forms of fruit are allowed Fruit drinks and black tea or coffee are

also permissible Butter eggs milk cream fish meat and salad dressings are not allowed At 9 p m 4 grms of the opaque salt are mixed with half a tumbler of water and swallowed in one draught Water may be taken freely after this and I have found alkaline waters such as Vichy and Vittel very effective in reducing the degree of nausea and the possibility of vomiting

The patient may have weak black tea or coffee on the morning of the examination but no solids The X ray examination is carried out at 11 a m i e 14 hours after ingestion of the dye If there is no shadow or only a faint shadow visible at this period a soft picture of the abdomen is taken to see if there is much unabsorbed dye in the intestines If there is a further 4 grms of dye are given to the patient to be taken with a fat free lunch A fat free dinner is allowed and he returns fasting the following morning

Intensive Oral Cholecystography

There are many variations of the intensive or double dose oral method In most people the single administration of 4 grms in one dose gives a good *concentration and this method has the great advantage of simplicity* Many workers follow modifications of a technique devised by *Stewart* and *Illick* and give small quantities of the dye over a period of two or three days during *which period the patient must live on a completely fat free diet* *This is a* complicated procedure and unsuitable in many patients whose ideas of fats and non fats are peculiar Recently *Whitaker* has shown that the gall bladder *is completely full of concentrated bile in 24 hours and therefore there is no* point in administering the dye over a longer period than this as it does not add to the concentration

The author s technique is simple for the patient and usually gives a sufficiently good concentration for the gall bladder to be visualised on the screen with a compressor The day before the examination the patient has a normal lunch not fat free and immediately after this meal takes 2 grms of the dye At 7 p m the patient has a fat free dinner and takes 4 grms of the dye an hour after this During the evening a bottle of alkaline water is drunk and the patient presents himself for the examination between 10 and 11 a m *the following morning If the first pictures in the prone position show a good* shadow one further picture is taken in the erect position a meal of three eggs in milk and a teaspoonful of sherry is given and further pictures taken 5 10 and 30 minutes after ingestion of this fatty meal The complete examination takes about an hour In some cases the gall bladder contracts very slowly and an hour and a half to three hours may be required to obtain all the necessary data

CHAPTER XXVIII

THE PATHOLOGICAL BILIARY TRACT

CONGENITAL MALFORMATIONS

A STUDY of comparative anatomy reveals extreme developmental variations of the biliary tract in animals Thus the horse and the rat have no gall bladder while the cow and the mouse have The pigeon is the only bird without a gall bladder but it has one during fœtal life One would expect to find the human biliary tract showing many developmental abnormalities but this does not appear to be the case *Boyden* in 19 000 autopsies found five cases of double gall bladder with a single cystic duct X ray reports of double gall bladder are very rare *Braunschweig* has described such a case, with the shadows of the two gall bladders superimposed in the postero anterior view One concentrated the dye much better than the other Oblique views after a fatty meal showed the two gall bladders contracting well and lying well clear of each other The ducts were not very clearly visible but his pictures suggest that there was a separate cystic duct for each vesicle A bifid gall bladder is also known a longitudinal septum dividing the gall bladder into two separate sections *Hartung* has demonstrated radiologically a very unusual anomaly the gall bladder attached to the left lobe of the liver *Hartung's* pictures show a normal gall bladder lying on the left side of the spinal shadow parallel to the lesser curvature of the stomach Complete absence of the gall bladder has also been described in man this defect is usually but not always accompanied by gross dilatation of the common duct

The most frequent congenital anomaly seen on radiograms is a septum extending across the fundus This septum may be minute or it may almost divide the fundus into two separate chambers In the average case there is a deep indentation on the fundus rather similar to an incisura on the greater curvature of the stomach and the gall bladder assumes a shape aptly described as resembling a Phrygian cap This deformity is probably of no clinical significance although some workers believe it may predispose to gall-stone formation

Flint has described various deformities of the bile ducts and of the right hepatic cystic and gastro duodenal arteries There may for example be a double cystic duct and a single common duct or there may be a single cystic duct and two common ducts The implantation of the cystic duct into the common duct may also take an abnormal course Few of these abnormalities have been detected radiologically probably because the function of the gall-bladder and the visualisation of the ducts have not been investigated as a

I11 4 D 1 l log ll l la l ler—b th ve cles are c oncen trat g ive normally

Fig 25—This is probably a case of doubl or bifi l gall bla l ler one locul s cont ur ng 3 stones This case is s milar to Bra ms l veig s (see p 3 0) No op rative confirmatio i

FIG. 220.—A characteristic example of the Phrygian cap deformity. No biliary symptoms.

routine. With modern technique, however, it is to be expected that more radiological reports of these anomalies will be described in the near future. A rare congenital abnormality is obliteration of the bile ducts. Such cases of icterus neonatorum do not live very long, and obviously the abnormality cannot be detected by cholecystography.

CHOLECYSTITIS

Cholecystitis may be acute or chronic. There are many varieties and degrees of intensity.

The acute type may be catarrhal, suppurative, ulcerative, phlegmonous or gangrenous, but irrespective of the type cholecystography is contraindicated in all acute cases. The dye may aggravate the inflammation, and in any case there is bound to be failure to concentrate it. A plain radiogram of the gall bladder region may be helpful by revealing opaque calculi.

Chronic cholecystitis may follow the acute form, or the disease may be chronic from the first. It may be part of chronic catarrh of the ducts, and it may or may not be associated with gall stones. The chronically inflamed gall bladder is usually distended with mucus, its walls are thickened, and its mucosa is thrown into heavy folds. Rarely the gall bladder becomes shrivelled up and small (*cholecystitis obliterans*). In cases where the cystic duct is blocked by a stone, the gall bladder becomes permanently distended, its walls atrophy, and eventually become a thin sheet of fibrous tissue like parchment. The visibility of the dye in the gall bladder is entirely dependent on the power of the gall bladder to concentrate. If, therefore, we find complete absence of a shadow after proper technique, the dye has either not reached the gall bladder *because of obstruction of the cystic duct, or the dye has reached the gall* bladder, but the mucosa is so extensively damaged that it cannot concentrate it. In either case the gall bladder is a surgical one. It has been suggested that non-visualisation occurs in the later stages of pregnancy due to pressure; recent work has not substantiated this suggestion. Not much is known about the effect of extensive liver disease on the concentration of bile in the gall bladder. *Whitaker* found in dogs with extensive liver damage a normal concentration of the dye in the gall bladder, but clinical experience does not

altogether support this idea The effect of any acute abdominal condition *on the mechanics of the biliary system is impossible to estimate, but* the consideration is of no importance, as cholecystography is contraindicated in such cases It can be stated without reservation that complete non visualisation indicates a gross lesion of the biliary tract and is an indication for surgery

Mild Chronic Cholecystitis —We must discuss now these cases of mild cholecystitis which constitute the greatest radiological problem The so-called lipoid cholecystitis (strawberry gall bladder—cholesterosis) is extremely common *MacCarty* found 936 cases of this disease in 5,000 excised gall bladders *Rolleston* and *McNee* summarise the pathology as follows "From *lymphatic obstruction the villi become loaded with cholesterol absorbed from* the gall bladder bile Externally the gall bladder is normal except for an enlarged gland near the cystic duct, internally the papillæ appear as yellow streaks from contained cholesterol-ester, and so resemble strawberry seeds, they break off, and so may form the nucleus of future calculi" *Neuman* does not consider the condition worthy to be elevated to the position of a disease although *Moynihan* once described it as a "disease of the gall-bladder requiring cholecystectomy" *Newman's* opinion would appear to be that the condition is a mild inflammatory process consequent on a mild infection of the gall bladder, but that possibly it may be due to metabolic or dyskinetic causes The evidence in favour of the latter causes is so far inadequate

Radiologically therefore we are faced with a condition which we know to be *common and which, even when trivial, must be associated with some disturbance* of the biliary function In a cholecystographic examination we see three points by which we can estimate the biliary function (1) the rate of filling of the *gall bladder*, (2) *the capability of the gall bladder mucosa to concentrate the* bile as evidenced by the intensity of the shadow, (3) the rate of emptying of the gall bladder

(1) The Rate of Filling of the Gall bladder —It is obvious that the rate of filling, i e the rate of appearance of a shadow, can never be estimated accurately by the oral method and indeed this is a strong argument in favour of using the intravenous method in the "doubtful" cases Following a properly administered intravenous injection of the dye, a faint but obvious shadow should be seen four hours later, and the shadow increases in intensity for another four hours This average rate of appearance of the shadow has been proved, and if we add as a liberal margin another two hours as being within the normal limits we can state that if there is no shadow visible after six hours there is disturbance of the function of the liver or gall bladder or both Bearing in mind that experiments on animals with artificially damaged livers do not show much delay in the rate of appearance of the shadow, and that in most cases which we examine it is safe to assume that there is no gross liver

disease it follows that delay in the rate of filling is due to disturbance of the gall bladder itself. In view, however, of *Cullinan's* work on the frequency of sub-acute necrosis of the liver, the possibility of the liver being at fault should not be entirely excluded.

(2) THE INTENSITY OF THE SHADOW.—Unfortunately, we have no standard criterion by which we can measure the intensity of the shadow. Some workers compare the shadow of the gall bladder with the shadow of a transverse process, and others use the kidney or liver shadows as a standard. These criteria are too unreliable for general purposes, and the estimation of the intensity of the shadow must always be a personal one. There can be no possible doubt of a very faint shadow—it means either that the gall bladder is full of mucus or that its mucosa is sufficiently damaged to prevent normal concentration. What one may term a poor shadow is one of the most difficult problems set to the radiologist. It is impossible to dogmatise on this question, and perhaps the wisest course is not to diagnose pathology in these cases on the intensity of the shadow alone, although statistics for the Mayo Clinic show that the poorly filling gall bladder is pathological in approximately 95 per cent. of cases. There is conclusive evidence that a strawberry gall bladder may give a shadow of normal intensity.

(3) THE RATE OF EMPTYING OF THE GALL BLADDER.—There is a conflict of opinion on this question, some workers believing that the strawberry gall bladder empties too quickly, and others that it empties too slowly, the majority being of the latter opinion. We can only estimate the value of this sign if the examination is carried on until the gall bladder is completely emptied. It is not safe to assume that if the gall bladder contracts down to half its volume after a fatty meal the elasticity of its walls is intact. There are many cases in which the gall bladder makes one vigorous contraction after a fatty meal and then relapses into a condition of atony with stagnation of the residual bile for a long period. *Nemours Auguste*, who has investigated this problem very thoroughly, thinks that in females the normal gall bladder should be completely emptied in an hour after a fatty meal and in males in an hour and a half. Any longer period he considers to be evidence of disturbance of the biliary function. These standards are rather severe, and most workers would prefer a longer period, say, three hours. *Nemours Auguste* also stresses the appearance of the dye in the gall bladder in the usual prone position. If there is concentrated dye only at the fundus and if the intensity of the shadow diminishes progressively from below upwards, he considers there is some pathology present. This sign is of doubtful value, as in a normal gall bladder there may be as much as 20 c.c. of mucus secreted and floating on top of concentrated bile. In these mild cases of cholecystitis the clinical and X-ray findings must be carefully correlated. If a thorough examination has been made and the gall bladder fills slowly, empties slowly, and gives a shadow of weak intensity, it is safe to diagnose cholecystitis.

GALL-STONES

Gall stones are composed in varying proportions of cholesterol bile pigments and calcium salts There are *probably many factors essential for the* formation of stones but the most important ones are infection and biliary stasis Cholesterol is the dominant element in the *majority of gall stones* and this is a substance non opaque to X rays In many cases however there is either a central dense nucleus or bilirubin calcium is laid down in thin layers over the cholesterol Direct visualisation of gall stones is dependent on the quantity of bile pigment and calcium salts present *In the pre cholecystography era* skilful workers estimated that they could visualise about 40 per cent of gall stones but *this* proportion even with modern technique is much too high and 10 per cent *would* be a fair estimate Stones composed almost entirely of cholesterol can sometimes be *visualised* as so called negative shadows but this diagnosis unsupported by cholecystography is never *more than a possibility* as there are so many possible causes of negative shadows in radiography of the right hypochondrium

Fig 227 —Laminated stones in the gall bladder and one *in the cystic duct Oral cholecystography shows poor concentration from associated chronic cholecystitis*

Occasionally gall stones are seen which may be composed of about 90 per cent of calcium carbonate and 10 per cent of cholesterol These stones are of two types white and green The white ones are soft, and associated with obstruction of the cystic duct , the green ones contain copper in addition to *calcium carbonate and are associated with some general metabolic disturbance*

Gall stones are usually multiple and vary in size from a grain of sand to a florin The smaller the stones the greater the number pre

monest human gall stone is the faceted stone. This is composed of a small round central nucleus surrounded by successive layers of cholesterol crystals. Layers of protein and bilirubin calcium are laid down here and there between the cholesterol, and these render the stones radio-opaque. On a radiogram this type of stone is moderately opaque, has a clear centre, a dense periphery and a polygonal or faceted outline. When the gall bladder is packed with these stones it has a mosaic appearance. Round stones are less common and tend to be larger. The round stone has a translucent centre and an outer layer of bilirubin calcium which appears as a white ring. The calcium may not surround the whole of the stone and only a fine semicircular or sickle shaped layer of calcium may be visible. The round stone varies much in size, but is seldom smaller than a pea, and may be as big as a florin. Multiple punctiform opacities, the so called bile sand, are not very frequent but are easy to diagnose as there is no other cause for opacities of this type in the right hypochondrium. Very rarely one sees a stone with a dense calcified nucleus and a non opaque cholesterol body, the latter visible as a negative shadow round the dense nucleus. The calcium carbonate stones are rare. They are usually single and round or barrel shaped.

FIG. 298. Ring-like gall stone with opaque nucleus and outer lamina.

Differential Diagnosis. — Gall stones may be confused with renal stones, calcified glands, calcified costal cartilages, intrahepatic calcifications, pancreatic calculi and suprarenal calcifications.

Renal stones and gall stones are not infrequently present together. As a rule renal stones are denser, larger and more irregular in outline than gall stones, but occasionally gall stones very similar to renal stones occur. The differential diagnosis can be made directly by taking pictures in different phases of respiration and in different postures. The gall bladder has a wider range of movement during respiration than the kidney. In the prone position a gall stone may be superimposed immediately over the renal pelvis, but if the patient turns about 30 degrees to the left, i.e. with the right side of the body tilted upwards and the left side in contact with the Potter Bucky, the renal

and gall bladder shadows are separated and a biliary opacity is projected in front of the kidney In the true lateral position a gall stone is seen anterior to the spine and a renal stone is superimposed on the spine In the supine position a gall stone moves upwards and outwards while a renal stone maintains its position relative to the spinal column Rarely renal stones lying in a large hydro or pyo nephrotic sac can be differentiated from gall stones only by carrying out a pyelography or cholecystography

Calcified glands in the abdomen are presumed to be of tuberculous origin Tuberculosis of the glands in the porta hepatis is almost unknown and generally speaking it is unusual to find calcified glands in the right hypochondrium Most abdominal calcified glands are in the mesentery and have a considerable range of movement The demonstration of this wide range of movement by compression is often a simple and effective method of diagnosis The calcification in glands is very often granular a form of calcification not seen in gall stones In doubtful cases a cholecystography solves the problem

FIG [illegible] 9—Five transparent (cholesterin) gall stones shown by oral cholecystography

Calcified costal cartilages vary enormously in shape and size *Rowden* has shown that they are often convex downwards and thus they may simulate the ring or semilunar type of gall stones The respiratory movement of the costal cartilages is so characteristic and so different from the respiratory movement of gall stones that difficulty in diagnosis can only arise with poor technique

Intrahepatic calculi are rare are usually multiple and are distributed over such a wide area that they cannot possibly be in the gall bladder They are composed almost entirely of calcium carbonate and are much denser than the average gall stone *Calcified hydatid cysts* in the liver and *calcified liver abscesses*

Fig. 230. Two calcified stones in the gall bladder, one very large.

show dense peripheral rings of calcium, and do not change their relative positions in the supine and prone positions. These calcifications are not often confused with gall stones, but may simulate calcifications of the gall bladder itself.

Pancreatic calculi are dense stones composed almost entirely of calcium carbonate. They are rare and usually multiple, with the greater number lying in the left hypochondrium. A solitary pancreatic calculus in one of the larger pancreatic ducts has an oval shape rather like a ureteric calculus.

Suprarenal calcification is rare but may be similar to gall stones. A cholecystography is the best method of making this differential diagnosis, although it can be done by pictures in different postures and different phases of respiration. A calcified aneurysm of the renal artery simulating a gall stone has been described.

Cholecystography and Gall-stones

In about 50 per cent. of cases of gall stones no shadow is obtained by cholecystography. This is due either to a stone blocking the cystic duct or to the gall bladder mucosa being so damaged that it cannot concentrate the dye. The exact diagnosis is not of great moment, as the complete absence of a shadow calls for surgical treatment.

In about 30 per cent. of cases the gall bladder shadow is faintly visible and the stones are clearly visible in it. Non-opaque stones are seen as round or faceted areas of translucency. If there are many of these stones the diagnosis is easy; if there are only a few the diagnosis may be very difficult, as gas shadows in the duodenum and colon cause very similar appearances. Oblique views and views in different postures with compression may solve the problem, but the most effective method is to complete the examination and study the gall bladder after a fatty meal. When the gall bladder is contracted, stones while still remaining inside its shadow alter their position and are usually

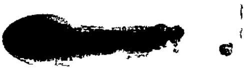
forced down to the fundus In the erect position stones usually, but not always fall down to the fundus

In about 10 per cent of cases the gall bladder concentrates the dye normally and the stones are visible in it The method of differentiating the stones from gas shadows is the same as in the previous paragraph It is sometimes

(a)

(b)

FIG 231 A case of chronic calculous cholecystitis Two stones were present in the cystic duct and the gall bladder contained opaque sand



(c)

(a) and (b) show the variable vermiform shadow cast by the gall bladder at a month's interval (c) is the excised gall bladder No concentration occurred with intensified oral cholecystography

erroneously stated that if there is normal concentration of the dye with stones the gall bladder is functioning normally and the stones are simply foreign bodies doing no harm It cannot be over-emphasised that the degree of concentration of the dye is no index of the proper function of the gall bladder—it simply means that there is enough healthy mucosa left to concentrate The rate of emptying of the gall bladder wi

always slow, taking often three or four hours to evacuate completely. This means that there is considerable fibrosis of the walls and is an indication for surgical treatment.

In about 10 per cent of cases a gall bladder containing cholesterol stones concentrates the dye normally and the concentrated dye conceals the stones completely. The first pictures are those of a normal gall bladder but during

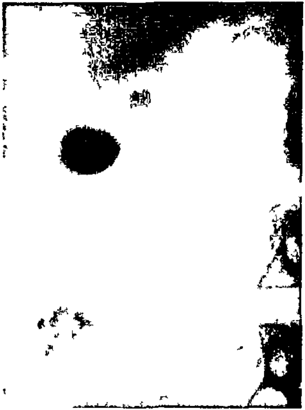


Fig. 239.—A case of chronic calculous cholecystitis. The large round opacity is caused by calcium carbonate sand in the fundus, the small one by a calcium carbonate stone in the cystic duct. A calcified gland is present below. No concentration occurred with oral cholecystography and analyses of the contents of the gall bladder excised a few days later revealed no trace of tetraiodophenolphthalein.

the phases of contraction the stones often reveal themselves as translucent shadows and there is delay in evacuation. Even then however such stones may be invisible with routine technique. As already mentioned some of these small calculi have a lower specific gravity than concentrated bile and float. In interesting papers *Ettinger* and *Brailsford* show how these calculi can be demonstrated in the erect position by gentle pressure with a compressor. In the erect position the concentrated bile falls to the bottom of the gall bladder and with gentle pressure the stones can be seen as small translucent shadows lying horizontally above this. The pictures should be taken with varying degrees of pressure. It is obvious that strong pressure will either force such stones up into the gall bladder mucus or down into the concentrated bile.

Stones in the common duct are very seldom visualised. Rarely the gall bladder may be seen full of faceted stones and one or two similar stones may be visible well away from the main shadow and in the line of the common duct. It may be assumed from the faceted shape that these stones developed in the gall bladder and passed into the duct. A stone developing in the common

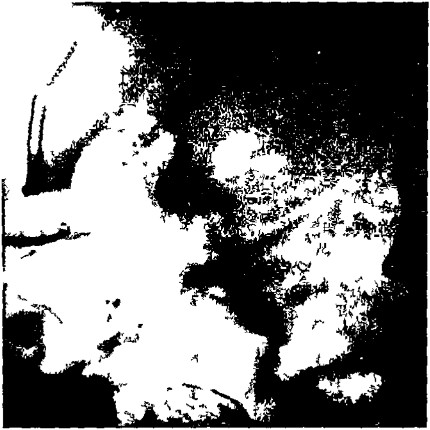
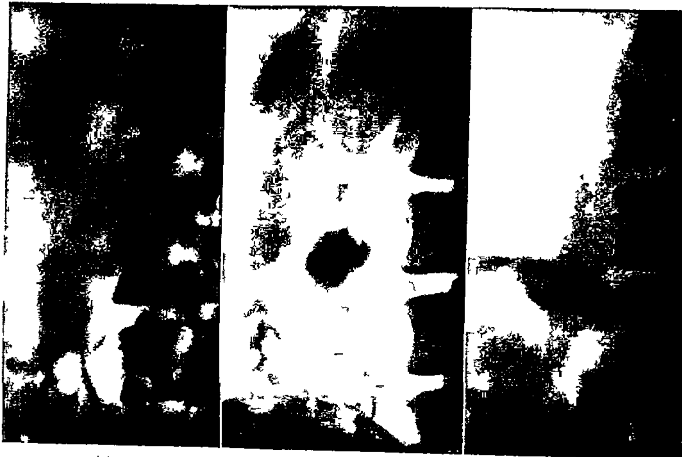


FIG 233.—Small calcium carbonate stones visible through a gas distended hepatic flexure in the oblique view

duct itself is oval in shape like a ureteric or pancreatic calculus. The differential diagnosis from a ureteric calculus is easily made by a cholecystography or a pyelography but it may prove impossible to distinguish between a pancreatic and a common duct calculus.

CALCIFICATION OF THE WALLS OF THE GALL BLADDER

This is a rare occurrence. It cannot occur without extensive pre-existing fibrosis and is therefore a sequel to a chronic cholecystitis. In the continental text books it is described as the porcelain gall bladder. The diagnosis is easy and the calcified walls are clearly visible on plain radiograms. The calcium is laid down symmetrically and the usual ovoid outline of the gall bladder is



(a) (b) (c)

FIG. 234.—(a) Prone position. Opacity similar to a calcified gland in front of the 3rd lumbar vertebra. (b) Oblique position showing the opacity to be formed of multiple gall stones. (c) Oblique position erect showing the stones lying in the fundus of the gall bladder. (C... f D... H... (...))

FIG. 235.—A case of multiple calcified gall stones (→) and numerous small calculi in the right kidney. These two collections of shadows were grouped rather closely together and are here shown differentiated by intravenous urography.

FIG. 236 (a).—An apparently normal gall bladder in the prone position.

FIG. 236 (b).—The same case erect showing floating gall stones. These appear as a thin translucent line above dense bile in the fundus. (*Case of Dr. J. F. Brailsford.*)

visible. It is possible that a calcified gall bladder of the round or sthenic type would give an appearance identical with a calcified hydatid cyst. Cholecystography will differentiate these two conditions, a normal gall bladder filling taking place in the case of hydatid disease. At a clinical meeting of the British

FIG. 237. Opaque faceted stones in the gall bladder, the cystic duct and the common duct. The faceted shape of the stones in the ducts shows that they migrated there from the gall bladder.

Institute of Radiology a case was shown in which two very large gall stones of the ring type simulated calcification of the walls. The differential diagnosis is not of importance, as both conditions are surgical. The calcified gall bladder either completely fails to concentrate dye or concentrates it feebly and slowly.

THE NON-CALCIFIED GALL-BLADDER VISIBLE WITHOUT CHOLECYSTOGRAPHY

Occasionally a well-defined gall bladder shadow is visible on a preliminary radiogram. It has the usual ovoid shape and can be clearly distinguished

from the liver and kidney shadows This appearance has been recognised and discussed for many years but we are *still uncertain* as to whether it represents disease in the gall bladder or not *Knox* was of the opinion that it was normal and he was supported by many workers in Europe Most American workers are inclined to the view that spontaneous visibility of the gall bladder is pathological If we consider the factors responsible for radiological visibility of an organ it is remarkable that the normal gall bladder is not seen more often Calcium is *excreted into the bile by the* liver in relatively large quantities Liver bile, according to *Neuman,* contains 60 mg of calcium per 100 c cm of bile and this is further concentrated in the gall bladder

FIG 238 —Calcification of the gall bladder

Although *Carman* was of the opinion that gall bladder bile was *no more opaque than* liver bile his experiments were not valid and there is no doubt at all but that gall bladder bile must be more opaque The quantity *of calcium in normal gall bladder bile is very often much* greater than the quantity in gall stones which can be clearly visualised Many workers ascribe the visibility of the gall bladder to a greatly increased concentration of the bile which is described as gall bladder mud This theory will not fit in with clinical or physiological facts *Whitaker* has shown experimentally that the gall bladder ceases *to concentrate after twenty four hours so* that even if there is stagnation for longer

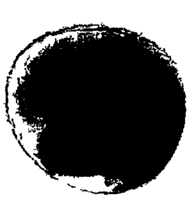
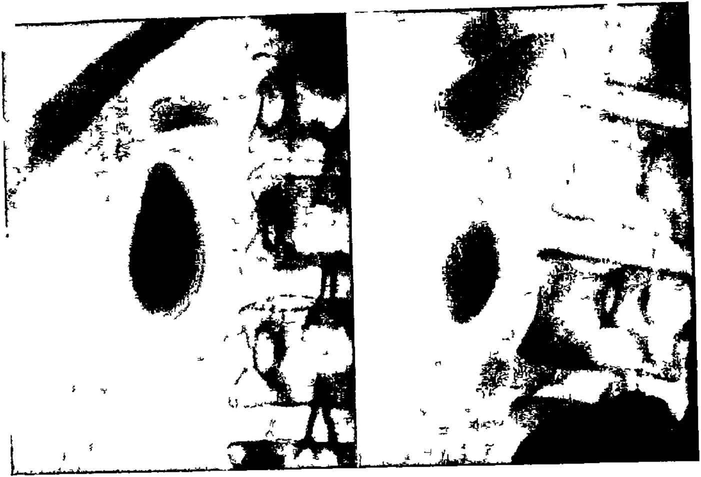


FIG 239 —Radiogram of the gall bladder shown in Fig 238 after its removal

than this period the density of the bile remains the same although it may look blacker and thicker to the eye It is an interesting fact that much fewer reports of spontaneous visibility of the gall bladder have appeared since the introduction of cholecystography It is obvious that the only certain method of checking the biliary function is by cholecystography and this should be done in all these cases The radiological diagnosis of gall bladder mud should be discarded

BILIARY DYSKINESIA

The neuro muscular mechanism of the gall bladder and ducts has already been described in the chapter on the normal Disturbances of this mechanism are not infrequent and cause symptoms very difficult to distinguish from symptoms of organic disease The possibility of functional disturbance being responsible for gall bladder pain was long suspected but it is only in recent years that the question has been adequately explored *Newman s* Goulstonian lectures give an admirable and exhaustive survey of the clinical problems involved It has been shown that overaction of the vagus causes spasm of the gall bladder and ampulla and cessation of the flow of the bile while stimulation of the sympathetic causes relaxation of the gall bladder and ampulla with contraction of the sphincter of Oddi and again no flow of bile The former condition causes spastic distension and the latter causes atonic distension of the gall bladder The symptoms in both cases are the same i e gall bladder pain It is obvious that in both conditions bile will flow normally into the gall bladder and will be concentrated there but in both cases there will be disturbance of the rate of emptying and probably dilatation of the common duct *Newman s* lectures were delivered before it was realised that the ducts could be visualised in most cases He describes the cholecystographic appearances of spastic distension as follows 'There is an opaque well filled well-concentrating gall bladder which diminishes after the fatty meal but does not disappear and which shows a delay in emptying In atonic distension cholecystography shows a very long thin gall bladder which throws a poor shadow and empties very little Spastic distension is associated with a hyper tonic stomach and hyperacidity while atonic distension is associated with a low atonic stomach and hypoacidity In both forms of the condition the common duct may be dilated and although the subject has been practically unexplored by radiology there are a few records by *Bronner* and *Nemours Auguste* showing such dilatation Moreover *Nemours Auguste* has demonstrated regurgitation into the intra hepatic ducts and there is no doubt but that the occasional reports of barium flowing into the ducts is due to some disturbance of the neuro muscular mechanism In the case illustrated in Fig 240 there is clearly a spasm in the middle of the cystic duct This type of dyskinesia does not appear to have been described before Now that we can demonstrate the ducts the radiological diagnosis of biliary dyskinesia is comparatively easy and cholecystography will at last throw light on those obscure



(a) (b)

Fig 240—Biliary dyskinesia Female et 30 Characteristic attacks of biliary distension (a) An apparently normal gall bladder and ducts 15 minutes after fatty meal (b) The same case 6 hours later and after two fatty meals Distension of the proximal part of the cystic duct The spasm is occurring at the junction of the muscular and glandular parts of the cystic duct

cases where there is definite clinical evidence of gall bladder pain with a normal concentration of the dye in the gall bladder There are many degrees and varieties of biliary dyskinesia—to appreciate these and their possible effect on cholecystography appearances the clinical picture should be studied in *Newman's* work

PERICHOLECYSTITIS (ADHESIONS)

In most cases pericholecystitis is a sequel to or a complication of cholecystitis Provided the gall bladder can concentrate the dye such adhesions can be demonstrated If the gall bladder in the prone position is parallel to the lower border of the liver adhesions between the fundus and the liver are *probable and if the same relationship is maintained in the erect position* adhesions are certain *Bronner* has demonstrated adhesions between the neck and the common duct with a ragged outline of the duct showing during the phase of contraction Adhesions to the duodenal cap and second part of the duodenum are not uncommon A gall bladder impression on the cap is not necessarily pathological but if this appearance persists and if the cap is irregular in outline there are probably adhesions present Adhesions to the second part of the duodenum displace the bowel upwards and to the right and in some cases tenting of the outer wall of the bowel is visible Occasionally an adhesion runs across the common and cystic ducts and prevents the cystic duct unfolding when the gall bladder contracts rather like a string being tied around a loop of hose pipe and preventing it unfolding when the pressure of water enters *John Hunter* in a personal communication states that he has seen three or four cases of this nature at operation There were typical symptoms of gall bladder distension with a normal cholecystography and at operation the gall bladder was normal The obstructive symptoms were entirely due to the small adhesion Had these cases been investigated by modern technique marked delay in emptying would have been found Occasionally an abnormal peritoneal fold the cysto duodenal or cysto colic ligament takes this course across the common and cystic ducts and it is possible that this ligament might cause similar partial biliary obstruction The question is of some importance as it is going to prove very difficult to distinguish between dyskinesia and distension due to adhesions or abnormal ligaments

Adhesions between an inflamed gall bladder and the hepatic flexure are not uncommon Such adhesions are nearly always associated with typical gall bladder pain and a cholecystography reveals a pathological gall bladder Rarely tenting upwards of the upper border of the proximal end of the transverse colon is visible There are occasional reports in the literature of cholecysto colonic fistulæ *Startz* and *Medelman* have described typical cases of this nature recently The patient complains of diarrhœa with a history of sudden onset of the diarrhœa The stools are frothy and brown to clay coloured There is some loss of weight and discomfort in the right hypochondrium In

both of the author's cases a barium enema passed normally round to the hepatic flexure and then filled the gall bladder and the biliary and hepatic ducts. Perforation into the small intestine does not appear to be so frequent. A barium meal will not necessarily flow from the duodenum into the gall bladder in such cases, and the meal may give no clue to the causation of the symptoms. Occasionally a large gall stone passes into the small intestine through such a

FIG. 241.—Several views of the duodenal cap showing a duodeno-biliary fistula. The gall bladder is filled with barium.

fistula and causes acute or sub-acute intestinal obstruction. The author examined a case of this nature and found one large stone clearly visible in the gall bladder. Although the history strongly suggested that another stone had been ruptured into the small bowel, this stone could not be visualised, and a meal gave no help other than the demonstration of distended coils of the small intestine. At operation a stone about the size of a shilling was found impacted in the ileum. Not infrequently a gall stone attack causes symptoms of

intestinal obstruction without any passage of stones into the bowel. The diagnosis of such cases is most difficult—if a barium enema reveals no pathology in the large bowel following an attack of apparent intestinal obstruction the radiologist should make a careful examination of the gall bladder area. Rarely gall stones rupture into the anterior abdominal wall. The author examined one case of this nature. The patient was an elderly woman complaining of abdominal pain and nausea with slight loss of weight. Clinical examination revealed a large hard mobile mass in the region of the hepatic flexure. A barium meal showed no abnormality of the gastro intestinal tract but there were three large gall stones of the ring type in the region of the palpable tumour. An oral cholecystography gave a completely negative result. At operation the three large stones were found embedded in the anterior abdominal wall and the gall bladder contained several small non opaque stones.

TUMOURS OF THE GALL-BLADDER

We are indebted to *Kirklin* for our knowledge of the X ray appearances of neoplasms of the gall bladder. *Small papillomas* are the most frequent. These give characteristic appearances. They are seen as small translucent defects usually on the lateral walls of the gall bladder. Their average size is about ½ cm and they are not larger than 1 cm. They are multiple and two or three appear to be about the average number present. The gall bladder in most cases concentrates the dye well. The defects always maintain the same relative position in the gall bladder irrespective of changes in posture or phases of contraction. The appearance in the filled gall bladder resembles stones or small pockets of duodenal gas. Stones however alter their position during the contraction of the gall bladder and duodenal gas can usually be eliminated by pressure or changes in posture.

FIG. 2[illegible]. Multiple papillomata of the gall bladder confirmed at operation.

Adenoma of the gall bladder is a rare tumour. It occurs most often in the fundus and appears as a single small semicircular or circular translucent defect in the fundus of a well filled gall bladder. An adenoma is best visualised when the gall bladder has contracted down and evacuated about half of its contents. Like papillomas an adenoma never alters its position.

Primary carcinoma of the gall-bladder is not common Statistics show that in most cases carcinoma develops in a gall bladder containing stones Cholecystography has not materially assisted in the diagnosis of cancer In most cases there is a completely negative filling, in some cases stones may be visible, without, however, any clue to the presence of a growth, and in one case *Kirklin* found a normal concentration of the dye *Taterka* has reported one case in which there was a filling defect of the outer wall and an indentation of the inner wall

Tumours of the bile-ducts are rare The author, in one case of primary carcinoma of the hepatic duct, found a complete failure of concentration

POST-OPERATIVE VISUALISATION OF THE BILIARY TRACT

This procedure has attracted more attention in America and the Continent than in England *The object of the examination is to determine the patency* of the common duct and the efficiency of drainage after choledochostomy It *is often very difficult to palpate small stones in the common duct at operation* Lipiodol, or some similar substance such as brominol, is slowly injected through the drainage tube *into the ducts under the screen* The reader is referred to a paper by *Hufford* for details of the technique It is imperative that the injection be made slowly and under the screen, as, if some of the opaque material is forced into the duct of Wirsung, it may precipitate œdema of the pancreas or acute hæmorrhagic pancreatitis When the opaque material has been injected pictures are made at intervals of fifteen minutes, and the patency of the common duct checked by the appearance of the lipiodol in the duodenum The calibre of the common duct and the time taken for the flow of lipiodol into the duodenum are carefully observed, particular attention being paid to the presence or absence of small defects in or constrictions of the common duct The intrahepatic ducts are often filled These appear rather like the lipiodol filled bronchi, progressively diminishing in size, and terminating in fine sharp pointed arborisations Dilatation of the intrahepatic ducts with clubbing of the terminal branches is an indication for prolonged drainage, and also signifies that the biliary infection necessitating operation was present for a considerable time

DISEASES OF THE LIVER

The visualisation of the liver and spleen by direct radiography is unsatisfactory It was found that radio active substances, when injected into the blood-stream, tend to be retained in the reticulo-endothelial system—as these substances are of high specific gravity they are radio-opaque, and one of them, thorotrast, has been employed for radiography of the liver and spleen The results obtained did not materially assist diagnosis or research, and as the half value period of thorotrast is high and the substance is known to be carcinogenic in animals, the method is falling into disuse

More important, from the radiologist's point of view, are the liver necroses. In acute liver necrosis, cholecystography is contraindicated. There are, however, cases of idiopathic jaundice associated with subacute necrosis of the

FIG. 243. Lipiodol cholangiogram in a case of biliary fistula following destruction of the common bile-duct. The gall-bladder had been removed. The irregular mass of lipiodol is on the skin and in the sinus, and the thick straight tube represents the dilated hepatic duct.

liver. There are many degrees of subacute necrosis, and the condition does not appear to be very rare, *Cullinan* having recently published twenty proven cases. The etiology is completely unknown, bacterial infections, syphilis, alcoholism and drugs having been excluded. In some of *Cullinan's* cases

cholecystography was carried out and showed either a poor concentration or a complete failure to concentrate This was interpreted as being due to a pathological gall bladder but *Cullinan* thinks it was more likely due to a damaged power of excretion of the liver itself This finding is of much interest because (*a*) it shows that cholecystography is not necessarily dangerous in cases *of jaundice and (b) it reveals another and apparently not infrequent condition* which may be responsible for poor or absent concentration If *Whitaker s* and *Fried s* experiments on dogs are valid in human beings cholecystography will not cause distress and the dye will be concentrated normally when roughly half the liver is put out of action by necrosis Generally speaking it is wiser in cases of jaundice to make use of the single dose oral method

THE GALL-BLADDER AFTER CHOLECYSTOSTOMY

Jenkinson and *Foley* followed up a series of 28 cases who had had surgical drainage of the gall bladder They found 19 concentrated the dye normally and contracted normally after a fatty meal Seven showed feeble concentration or *complete failure to concentrate and 2 showed a normal concentration with* visible stones

THE EFFECT OF EXTRABILIARY DISEASE ON CHOLECYSTO GRAPHIC FINDINGS

Most text books on the radiology of the biliary tract cite numerous extrinsic *conditions* as being *potential causes of failure of the gall bladder to concentrate* the dye *Cullinan* has shown that the gall bladder will to some extent con centrate the dye in cases of advanced liver disease *Newman* has established that in the neuro muscular disturbances of the biliary tract there is no failure to concentrate although such dyskinesias are frequently associated with func *tional disturbances of other organs It has been stated that the gall bladder* does not concentrate the dye in the late stages of pregnancy but this requires verification on a large series of cases with the intravenous technique In a very interesting paper *Good* and *Kirklin* analyse the cholecystographic findings in 733 cases of peptic ulcer pernicious anaemia thyrotoxicosis myxoedema *diabetes obesity pulmonary tuberculosis and chronic appendicitis Of the* 733 cases 107 had abnormal cholecystographic findings in the form of a poor or absent shadow Of these cases 104 had the gall bladder examined either at operation or autopsy and the cholecystographic findings indicating gall bladder pathology were confirmed In only 2 of the cases was a normal gall bladder *found at operation i e an error of 1 9 per cent These findings show that* extrinsic diseases both metabolic and abdominal have little or nothing to do with the ability of the gall bladder to concentrate and excrete the dye The majority of errors in diagnosis are made on the interpretation of poor shadows such errors would soon be eliminated if radiologists checked their poor shadow *findings in the operating theatre*

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PART THREE

THE ABDOMEN

BY

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PART THREE

THE ABDOMEN

CHAPTER XXIX

THE LIVER, SPLEEN, PANCREAS AND ADRENALS

THE LIVER

General Hepatic Enlargement—*This may be due to many causes, such as congestion cirrhosis tumours or hydatid disease*

There are certain anatomical features in the liver of radiological importance The upper surface is in contact with the diaphragm the left border extending on an average half way across the left dome Its contour is therefore clearly visible in a radiogram except where its shadow fuses with that of the heart The right surface is in contact with the lateral abdominal wall, and can usually be made out in a film of good quality Frequently also the anterior and right lateral margins of the liver are visible The outline of the anterior margin gradually disappears to the left In spite of this, accurate estimation of slight or even moderate enlargement is impossible, because of the varying obliquity of the inferior surface Only when the enlargement is considerable can it be shown radiologically with certainty, and then the condition is evident clinically

The shape of the hepatic shadow varies with the habitus In hypersthenic subjects it is wide and shallow, and high in the abdomen In hyposthenics its transverse diameter is less its depth increased and the indentation of the waistline of the patient is frequently visible on the right The hepatic flexure and transverse colon if outlined with gas or barium may delineate the lower surface approximately but without any precision since they themselves are so variable in position *Loffler in 1914 pointed out that if the colon is inflated the transverse portion usually lies against the lower surface of the liver, and this provides a more accurate boundary mark* but the method is very seldom used now

Angulation of the tube so that its central ray is in the plane of the lower surface of the liver may intensify the shadow of the lower margin (*Köhler*)

Hepato-lienography—For this examination thorium is used as a contrast medium This element has an atomic number of 116 (atomic weight 232), and is one of the heaviest metals known In suitable non toxic combination it forms a dense and very satisfactory medium in relatively dilute solutions

It is used in two forms stable and flocculent The flocculent form diagnothorine is described in the section on the colon An example of the stable form is thorotrast described by the makers Heyden of Dresden as a stabilised thorium dioxydsol containing 25 per cent ThO_2 in sterile suspension and supplied in ampoules containing 25 c c It is miscible with water or normal saline without disturbance of the suspension

Thorotrast is used in two different classes of contrast medium work—intravascular and intralumenal In the former category are arteriography and hepato lienography in the latter are urography and demonstration of fistulæ empyema cavities etc

PROPERTIES —Thorotrast is very opaque to X rays even when diluted threefold this quality makes it of value when only a small quantity or a thin layer can be introduced

Although it was originally claimed to be quite non toxic in the doses recommended in intravenous or intra arterial injection and non irritant when introduced into the bladder and kidney one feature must be borne in mind—its radio activity This is very slight but since the reticulo-endothelial system stores thorium dioxide indefinitely when the latter is injected intravascularly late degenerative changes are apt to occur in the liver and spleen in the course of years Indeed numerous cases of such damage are now being reported in the literature It is therefore not a medium to be lightly used intravascularly This fear of damage by radiation does not apply in the other uses of thorotrast e g pyelography

ADMINISTRATION FOR HEPATO LIENOGRAPHY —A total dose of 50–75 c c of thorotrast is usually necessary given over a period of several days An initial intravenous dose of 10–15 c c depending on the size of the patient should be given slowly over three to five minutes on the first day As a rule no after effects result but occasionally slight headache and rise of temperature may occur Subsequent injections should be given daily if there are no after-effects and every second day if there are until the required dose has been given In the absence of symptoms it is safe to increase the daily dose to 20 25 c c but if after-effects have occurred it is better to keep the dose low

The radiographic examination should be made one or two days after the last dose to allow concentration of the drug to take place in the reticulo-endothelial system The radiographic technique should be directed to obtaining the greatest possible degree of contrast since the degree of concentration is not great

RADIOGRAPHIC APPEARANCES —These have been described by *Ladislav Lohcer* As a result of the fixation of the thorium salt by the cells of Kupffer in the liver and spleen these organs cast a much denser shadow than normally and their outlines in a radiogram become clearly defined

The chief value of the method is in the demonstration of hepatic metastases These since they do not become impregnated with thorium stand out as clear

areas in the hepatic shadow Hydatid cysts are similarly delineated *Volcer* states that in advanced cirrhosis of the liver the concentration of thorium is poor and that the physiological rhythmic contractions of the spleen can be observed fluoroscopically The method is said by *Volcer* to be contraindicated in diseases of the reticulo-endothelial system

Thorotrast hepatography and pneumoperitoneum may both give accurate information regarding the liver but the now well known damage which thorium may do to the reticulo-endothelial system precludes its use in the vast majority of cases and the information obtained by the latter method is usually not worth the inconvenience of the examination

Abscess of the Liver —The small multiple metastatic abscesses following on pylephlebitis or ulcerative endocarditis give no radiological signs The larger amœbic abscesses may cause enlargement of the liver and elevation and fixation of the right dome The nearer the abscess is to the upper surface of the liver the more definite are these signs The dome is not usually deformed even with a subdiaphragmatic liver abscess but in this type the differential diagnosis from subphrenic abscess may be impossible

Carcinomatous metastases of the liver are very common Apart from the advanced cases in which a mass can be seen projecting from the lower margin of the liver and the extremely rare calcifying metastases radiology is of little help Any general enlargement shown in a radiogram is also evident clinically Thorium hepatography is now regarded with disfavour even in this condition It shows intrahepatic metastases clearly and may by doing so spare the patient an unnecessary laparotomy In such a case thorium damage is of no consequence but if no metastases are present and the primary lesion in the alimentary canal is removable the damage caused by thorotrast is of importance and the method should therefore be avoided

Calcification in the Liver —The liver is the common site of hydatid cysts They may be multiple and reach a large size If near the upper surface a cyst may cause a localised rounded elevation of the diaphragmatic contour and if near the anterior margin a rounded downward projection of that edge (*Harrison*) More commonly however they are not radiographically recognised until they become calcified as often happens As the wall calcifies an irregular trabeculated ring shadow of the wall appears the arrangement depending on the distribution of calcification and the arrangement of the cysts

Limard reports a case of tuberculous abscess of the liver which had undergone calcareo sclerosis and cast an irregular shadow simulating gall stones

Freese reports two cases (1) Opacities the size of cherry stones scattered throughout the liver and thought to be due to calcified tuberculous foci (2) A large irregular calcified mass capping the upper surface of the liver from a calcified subphrenic abscess

Other conditions in the liver which may rarely become calcified are hæmangioma and lymphangioma abscess gumma and metastatic carcinoma

THE SPLEEN

Anatomy—The spleen lies posteriorly in the left hypochondrium between the gastric fundus and the diaphragm. It is an oblong flattened body about 5 inches long, 3 inches broad and 1.5 inches thick. It is held in position by the lieno-renal ligament and the gastro-splenic omentum. The outer convex surface is in contact with the diaphragm, which separates it from the ninth, tenth and eleventh left ribs. Its inner surface is divided by a ridge into an anterior or gastric surface and a posterior or renal. Two other relationships may be noted, that of the lower pole of the spleen to the splenic flexure of the colon, and that to the tail of the pancreas. The long axis of the spleen runs from above downwards, outwards and forwards.

Radiological Appearances—The normal spleen is visible only if contrasted medially against gas or other medium in the stomach and/or colon. Usually its upper pole is to some extent visible against the gastric gas bubble, and if the splenic flexure is distended with gas its whole inner contour may be seen, but percussion and palpation give such accurate information regarding its position and size that radiographic examination is seldom, if ever, necessary.

If it is necessary to demonstrate the spleen radiologically, the patient should be screened to determine which view (postero-anterior, oblique or lateral) shows it best, and whether it is necessary to inflate the stomach and colon. Its normal outline is usually semilunar, but may vary according to the angle at which it is projected.

Ptosis of the Spleen is not an infrequent occurrence and is demonstrated only in the erect posture. Enlargement of the spleen is easily detected clinically, and its radiological signs, in addition to the increase in its shadow, are those of displacement of the stomach to the right and of the left colon downwards.

Calcification in the Spleen may result from various lesions, including the following: tuberculosis, infarct, hydatid disease, phlebolith.

Calcified Tuberculous Foci appear as multiple rounded irregular shadows, usually small in size, scattered in the splenic shadow. In the case reported by *Spitz* the opacities were small and sharply defined, and the calcification well advanced. In one of *Shards* three cases the opacities were larger and somewhat woolly, due to active caseation in addition to the calcification.

Splenic Infarct presents a typical radiological appearance when calcified. Although infarcts are not uncommon, calcification in them is, and so is rarely seen in an X-ray department. *Kadrnka* and *Babiantz* describe the following features in three cases seen by them. The calcified lesion is of considerable size, located in the spleen, of triangular or oval form, and may be single or double. The texture of the calcified shadow is not homogeneous, but rather porous. If triangular in shape, the base is to the outer convex surface, and

its apex towards the hilum The contours of the triangle are sharply defined, with minor irregularities only

The shape of the infarct as seen in a radiogram—oval or triangular—depends on the angle at which the pyramidal lesion is projected on the film

Hydatid Cysts cause enlargement of the splenic shadow if not calcified, and, in addition, the typical trabeculated ring shadow if they are

Phlebolitths are said to result from venous thrombi They appear as small rounded shadows varying in size from 1 mm to 1 cm and may be multiple, as in the case reported by *Koppenstein*, or single as in one case noted by the writer

Rare causes *of calcification* which have been described are atheroma of the *splenic artery* and perisplenitis

Fig 244 —Three splenic stones

THE PANCREAS

Anatomy. — The pancreas lies transversely on the posterior abdominal wall in the epigastric and left hypochondriac regions at about the level of the first lumbar vertebra Its downward turned head, the largest part of the gland, is closely encircled by the duodenal concavity for about two thirds of a circle Radiologically, the most important anterior relationship of the pancreas is the *stomach, which lies in front of most of it, separated from it by the lesser sac* The duct of Wirsung opens into the second part of the duodenum, 3–4 inches from the pylorus, either directly or into the ampulla of Vater The common bile duct, *as it approaches the ampulla, is also closely related to the pancreatic* head

Technique of Examination —The pancreas is a difficult organ to examine radiologically, and a variety of measures may be necessary, depending on the lesion in question They are

(1) *The Plain Postero-anterior Film* —This may show gross enlargement or calculi, and in acute pancreatitis may give confirmatory signs

(2) *The Barium Meal* may show a gastric or duodenal pressure *Twining's method is of particular value here In this method the*

Fig 245 —The posterior (pancreatic) incisura of Twining postero anterior supine view

well filled with barium emulsion is radiographed in the lateral (dextro sinistral) view, with the patient lying supine, and the rays horizontally disposed A Schonander grid is used

Twining points out that in many ptotic women a normal incisura is present on the posterior wall of the stomach at the level of the pancreas (the ' posterior pancreatic incisura) This shows itself in the postero anterior supine view as an indentation of the greater curve sometimes extending right across the stomach but more frequently fading away towards the lesser curve (Fig 245) In the lateral supine view this incisura is seen to be an infolding of the gastric wall at the pancreas surmounting a triangular filling defect due to the pancreas itself (Fig 246)

The recognition that there is normally a triangular defect present in addition to the incisura proper is of importance in assessing the presence or absence of one due to a tumour of the pancreas or stomach bed

(3) *Fluoroscopy of the Diaphragm and Lung Bases* should be carried out if an acute pancreatitis is examined radiologically

(4) *The Barium Enema* may give evidence of steatorrhœa in chronic pancreatitis

(5) *Lateral Radiography with Air inflation of the Stomach* — The technique for this last according to *Engel* and *Lysholm* is important as follows

The colon should be well cleared out and the stomach empty The stomach is inflated via an Einhorn tube (which may first be used to empty it) and the patient told not to belch If the patient objects to the passage of the tube an effervescing powder may be used but this necessitates swallowing some water which is a disad

Fig 246 —The posterior (pancreatic) incisura of Twining lateral supine view

vantage Whichever method is used, the lateral radiogram *must* be taken *immediately* after the inflation, before any appreciable quantity of gas has escaped into the small intestine In that site the gas may cast confusing shadows

The patient should lie prone with the chest and pelvis supported by flat pillows or pads to prevent undue pressure on the air filled stomach Alternatively he may be supine, but this position gives a less prominent shadow of a tumour

The tube is centred horizontally on the right loin, and the film placed on the left A Schonander grid may be used with advantage Immediately following this, the essential view of the technique, a prone postero anterior view with grid may be taken to determine any lateral displacement of the air filled stomach or tumour shadow in air relief

Engel and *Lysholm* in a series of investigations of the normal, using 100 cm tube film distance found that the average "pancreatic space" between the spinal and gastric shadows approximately equalled the width of the adjacent vertebral body In enlargements of the pancreas this is widened, and the contours of the enlargement seen against the air filled stomach

Of the two methods *Twining's* would appear to be the better, since it avoids the use of the Einhorn tube and since barium is a better contrast medium than air In large tumours the Scandinavian technique might be used with barium as the medium instead of air

Acute Hæmorrhagic Pancreatitis —This is an abdominal catastrophe with a high mortality, and is rarely examined radiologically It most commonly results from retrograde infection along the duct of Wirsung from biliary disease The most severe types may die from collapse in twenty four hours If they survive the initial shock, abscess formation hæmorrhage into the pancreas, and fat necrosis are typical features

Haring states that an antero posterior film may show blurring of the outer margin of the left psoas muscle in its upper part, from the enlarged gland, and also that the left dome of the diaphragm is immobile or nearly so According to *Udvardy*, bilateral basal pleuritis and pneumonitis may occur from acute pancreatitis with abscess formation similar to that seen on the right side in subphrenic abscess If a pancreatic abscess contains gas, it might be visible in a lateral supine view, which view may also show an enlarged pancreatic space, if the stomach contains air

Chronic pancreatitis gives no localised radiological signs since it rarely, if ever, causes pancreatic enlargement Steatorrhœa is sometimes a feature of this condition and may present a honeycomb or polypoid appearance in the colon after a barium enema (*Stenstrom*) *Careful lavage before the examination will differentiate this appearance* due to retained fat, from true polyposis of the colon

Pancreatic Cysts —These are rare *Grey Turner* classifies them as follows

TRUE CYSTS

Acinous —(1) Retention (2) Cystadenoma (3) Congenital cystic disease

Interacinous —(1) Lymphatic (2) Parasitic

FALSE CYSTS

Intraperitoneal —Inflammatory effusions into the lesser sac from injury or pancreatitis

Retroperitoneal the result of breaking down of new growth or hæmorrhage or abscess of the pancreas

TRUE CYSTS —The retention type is the commonest and usually results from obstruction from chronic pancreatitis These cysts are commonly as large as an orange and may be enormous Hydatids are rare in the pancreas but also may be of considerable size

FALSE CYSTS —There are two types both of which may be large

(1) Loculated inflammatory effusions in the lesser sac in front of the pancreas

(2) Localised retroperitoneal effusion following the breaking up of the pancreas from old pancreatitis

RADIOLOGICAL FEATURES —A cyst if of some size may be visible in a plain postero anterior film In a lateral view with stomach filled with air it produces a rounded forward bulge into the gastric lumen

This pressure effect is also visible in a barium meal A varying filling defect is produced in the stomach the size of the defect depending on the size of the cyst and the degree of filling of the stomach Small cysts may produce no gap in the gastric shadow unless only a small amount of barium is present The defect is then seen in the pars media centrally or towards and involving the lesser or greater curve depending on the exact site of the forward protruding mass The defect fades away towards its margins and at the margins the mucosal folds are seen to be normal *Koller* points out that the stomach if filled sufficiently to blot out the defect shows an apparent increased flexibility to the palpating hand during fluoroscopy Very slight pressure is necessary to cause a gap in the barium shadow since only a thin layer separates the gastric walls at the site of the cyst In a case seen by the writer the same effect was noted with the patient prone when the defect invisible with the patient standing appeared

Large cysts may produce an extra-gastric defect which is not obliterated by complete barium filling or may cause a marginal defect with lateral displacement of the stomach A very large cyst may produce a gap extending right across the stomach *Gerth* records such a case in which the cyst was also visible as a faint rounded opacity in a plain film

A cyst near the head of the pancreas may cause a filling defect at the incisura angularis. *One in the pancreatic head provides a deformity similar to* that caused by carcinoma in that site.

Monauni has reported a case which showed first as a closed cyst, deforming the stomach. Later, after the cyst had ruptured into the stomach, a barium meal showed the cyst outlined with barium, and presenting three layers, of gas, pus, and barium.

Carcinoma of the Pancreas.—The common site for this is in the head of the pancreas, *where it produces typical* clinical and radiological features. The clinical picture is governed by the obstruction of the common bile duct with gradually increasing jaundice, distension of the gall bladder, and steatorrhœa.

FIG. 247.—Carcinoma of the head of the pancreas producing elevation of the pyloric antrum and widening of the duodenal circle.

RADIOLOGICALLY, the duodenum *shows widening of its circle, narrowing* of its lumen, and distortion of its plicæ. When the pancreatic enlargement is gross, the pyloric antrum may be raised and the duodeno-jejunal flexure depressed (Fig. 247). Gastric stasis is a common result.

Pancreatic Calculi.—These are rare. *According to Köhler,* they are found in the ratio of 1 in 2,000 autopsies. They have to be differentiated from the upper abdominal calcifications, renal and biliary calculi, and from calcified glands. They are commoner in males, and usually develop after the age of 30.

RADIOLOGICAL FEATURES.—Pancreatic calculi contain calcium, and are therefore visible in a radiogram. They are nearly always multiple, and are *scattered irregularly along the head and body of the gland. Their shape* may be fleck-like, pointed, faceted, mulberry, or (rarely) round. *Haring* records an annular form.

In a radiogram the shadows of pancreatic calculi are usually disposed transversely or obliquely across the middle abdomen at about the level of the second lumbar vertebra.

Graham Hodgson records a case of solitary calculus in the duct of Wirsung, diagnosed radiologically by combined cholecystographic and barium meal examinations. The former excluded gall-stones, and the latter showed the opacity within the duodenal circle, close to the ampulla of Vater.

Cole records a case of calcification in a carcinoma of the head of the pancreas *S A Sennett* records a case in which the calculi were large—up to 1 cm in diameter—irregular in contour and scattered throughout the length of the pancreas Their distribution made the diagnosis fairly definite

THE SUPRARENAL GLANDS

Anatomy—The suprarenal glands are two small flattened bodies capping the upper poles of the kidneys The right is more or less triangular in shape the left lunate They are about 1½–2 inches in length rather less in width and 1 2 mm thick The posterior surfaces of both are in apposition to the diaphragm above and to the upper poles of the kidneys near the lower margins The anterior surface of the right is related to the liver and inferior vena cava and that of the left to the stomach and pancreas

FIG 248 Perirenal inflation in a case of [illegible] The appearances are normal no adrenal enlargement being evident

The normal suprarenal glands are invisible in a plain radiogram but can be shown by the perirenal inflation method of Carelli (Fig 248) or by pneumoperitoneum When demonstrated by either of these methods they each present a characteristic outline

The two conditions in which the radiologist s help may be sought are in tumours of the gland and in Addison s disease

Adrenal Tumours—These are rare and are usually diagnosed clinically or radiologically only when they have reached some size as in hypernephroma and neuroblastoma They usually occur in children Isolated cases of glioma neuroma gliofibroma angioma lipoma and cysts have been described

The adrenal hypernephromas may be benign or malignant and are said to arise in the adrenal cortex (*Thomson Walker*)

Large adrenal tumours may give evidence of their presence in a plain film (1) by their own shadow (2) by downward displacement of the renal shadow Pyelography may show certain features According to *Cahill Loeb Kurzrok Stout* and *Smith* when the kidney is displaced downwards the upper pole is sometimes rotated inwards with the hilum facing downwards In nephroptosis and ectopia this rotation does not typically take place If invasion of

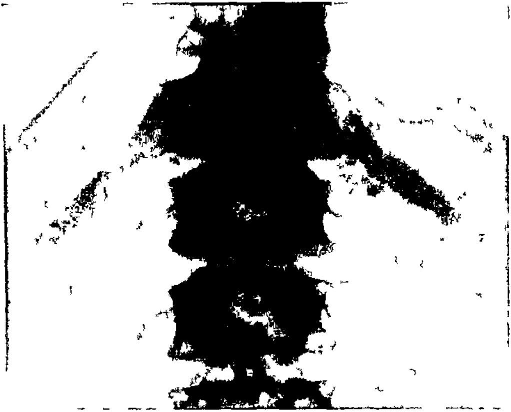

Fig 249 —Calcified adrenal bodies in a case of Addison s disease

Fig 250 —Calcification of the left suprarenal body in a case of Addison s disease

the upper pole of the kidney occurs distortion or obliteration of the upper calyces results in which case the differentiation from renal neoplasm may be difficult or impossible

Three other methods of demonstration of adrenal tumours have been used with success Perirenal inflation outlines the suprarenal capsule but is rarely used because of the technical difficulties The technique is described in the section on the urinary tract *Langeron* in 1929 demonstrated an adrenal tumour by pneumoperitoneum The radiogram must be taken with the patient prone *Roux Berger Naulleau* and *Condiades* (1932) injected in one case 40 c c of thorotrast into the aorta and by thus outlining the arterial supply of the kidney tumour and spleen were able to demonstrate the presence of a cortical adrenal tumour It is a moot point whether exploratory laparotomy is not a more satisfactory procedure than this last

Adreno-genital Syndrome —According to *Broster* this syndrome that of virilism is caused by either hyperplasia of the adrenal cortex or a cortical tumour both characterised by fuchsinophil cells The syndrome may appear when the tumour is quite small and in these cases plain radiography is of no help Perirenal inflation is then the only practicable method of X ray demonstration

Addison s Disease —When the tuberculous process in the adrenal gland has progressed to caseation and or calcification the latter can be shown radiographically *Ball Greene Camp* and *Rountree* out of twenty three consecutive cases successfully diagnosed six radiographically using a right oblique view for the left suprarenal and vice versa the tube being centred over the tip of the xiphisternum This technique avoids the superimposition of the shadows of calcified costal cartilages

From a combined study of films taken in vivo and of isolated post mortem specimens these authors classify the types of adrenal calcareous shadows as follows (1) gross calcification of the entire gland (2) discrete areas of calcification scattered throughout the gland (Fig 249) (3) homogeneous increase in the opacity from the gland The last is probably due to caseation To these three groups may be added that shown in Fig 250 in which the calcification outlines the gland like an incomplete trabeculated shell

I F Payne demonstrated caseation and calcification in three cases of Addison s disease one of them associated with gross tuberculous caseo calcification of the right kidney

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PART FOUR

FEMALE GENITAL TRACT

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PART FOUR

FEMALE GENITAL TRACT

CHAPTER XXX

X RAYS IN GYNÆCOLOGY

RADIOGRAPHY OF the female pelvic organs is employed as follows

(1) Simple or "direct"

(2) Combined with injection of some contrasting medium such as (i) Gas (ii) Opaque fluid (iii) Combination of (i) and (ii)

(1) DIRECT RADIOGRAPHY

The normal pelvic organs are not visible in ordinary direct radiograms Under certain conditions, neoplasms of the uterus and ovaries cause shadows in X ray examination of the pelvis The commonest neoplasm of the uterus is the *fibromyoma* which under ordinary conditions is of the same density as the surrounding tissues Calcification of the fibroid, when it occurs, will render it opaque to X rays and may be found in one or two varieties—(*a*) homogeneously throughout the tumour, or (*b*) more commonly in patches throughout the tumour or on the surface The opacity, of course, depends on the amount and the extent of calcification Calcification of fibroids tends to occur as a rule, after the menopause, and does not usually of itself give rise to symptoms *Calcified fibroids* (Fig 251) are therefore usually diagnosed more or less accidentally by X rays in cases which are being examined either as a routine or on account of obscure symptoms Calcification of fibroids is said to be a contraindication to X ray treatment, but from the foregoing it will be seen that, as these tumours do not give rise to the ordinary symptoms, their treatment by X ray therapy is not normally called for Calcified fibroids are frequently found to be subserous and pedunculated in which case surgical treatment may be indicated as a result of torsion, intestinal adhesions, or obstruction

One type of ovarian neoplasm the *ovarian dermoid*, is noteworthy in that it contains calcareous and ossified tissue in varying amounts, which may in favourable cases give rise to shadows Teeth are sometimes present, which may produce their characteristic X ray appearances

Calcified plaques may also occur in walls of simple ovarian cysts, these are unlikely to be disclosed by X rays, owing to their small size and the thinness of the calcified tissue

The relation of any doubtful opaque area in the pelvis to " ‥ ‥ ·

ureters may be investigated by cystography or ureterography (intravenous or retrograde)

Whether the tumour contains opaque material or not, its relation to the uterus can be demonstrated by means of utero salpingography supplemented where necessary by pneumoperitoneum A helpful procedure is that suggested

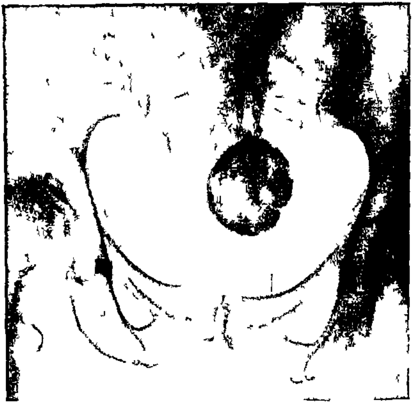

Fig. [illegible] Calcification in uterine fibroid

by *Beclere* namely the preliminary demarcation of the limits of the palpable tumour by means of lead wire fixed to the skin so as to surround the tumour

INJECTION OF CONTRAST MEDIA

It was discovered that the injection of a gas into the peritoneal cavity made it possible to outline those organs which abut on that cavity and any neoplasms inside by the contrast of density between the tissues of the organ or neoplasm and the surrounding gas

In women gas may be introduced into the peritoneal cavity via the uterus and Fallopian tubes or via the abdominal wall The former method is commonly employed in the diagnosis of the patency of the tubes in the investigation and treatment of sterility but is contraindicated in cases of pregnancy and

in infections of the uterus and tubes, when the latter route may be used

Air was the first gas to be used, but inasmuch as gas in the peritoneal cavity in any appreciable quantity gives rise to pain, and air is comparatively slowly absorbed (two to three days) it has been found that carbon dioxide gas is more satisfactory, being absorbed much more quickly (in a few hours)

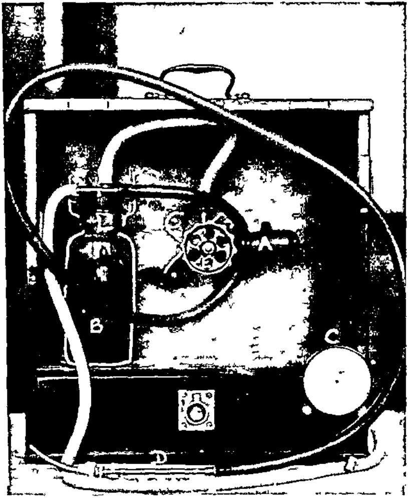

Fig 252—Provis apparatus A Sparklet B Bottle containing sterile warm water C Manometer D Rubin's cannula or hollow needle E Control wheel

Since *Rubin* first described the technique of transuterine inflation of the peritoneal cavity, numbers of different forms of apparatus have been described by various authors, using either air or carbon dioxide Most authorities insist on measuring the pressure at which gas is passed through—the importance of which will be seen later—and others also introduce a *flow meter* in order to ascertain the quantity of gas introduced

The apparatus described by *Provis* (Fig 252) has been used both for

transuterine inflation by means of the uterine cannula, and for inflation through the abdominal wall by means of a hollow needle

TRANSUTERINE INFLATION

This method is used almost entirely as a test of the patency of the Fallopian tubes, rather than as a means of inflating the peritoneal cavity

Contraindications

(1) The presence of an intrauterine pregnancy
(2) Menstruation
(3) Active infection of cervix or tubes
(4) Ectopic gestation hydrosalpinx or pyosalpinx

Careful bimanual examination should be made as a preliminary, preferably under anæsthesia This examination is usually made before inflation, as a preliminary to dilatation of the cervix, which is the routine treatment of sterility With ordinary antiseptic and aseptic precautions the procedure is practically harmless In a certain small percentage it is followed by evidence of pelvic peritonitis and cellulitis, which is to be ascribed rather to the unrecognised presence of infection than to the recent introduction of sepsis by operative procedure

The Technique—The writers use the apparatus designed by *Prous*

This (Fig 252) is prepared by placing a Sparklet tube of CO_2 in the appropriate holder, by filling the bottle up to two thirds with warm sterile water, and by attaching the manometer and the cannula to the tubes leading from the T piece passing through the stopper of the bottle The cannula is previously sterilised by boiling

The vulva vagina and cervix having been cleaned and painted with an antiseptic the cervix is seized with volsellum forceps and drawn down to the introitus for inspection A uterine sound is then passed to note the direction and length of the cavity of the uterus The cannula is then passed till the olive is firmly pressed into the external os, in practice this is found to give a gas tight joint

The stop-cock is then very carefully turned until it is seen that the gas is slowly passed through the bottle and into the cannula This passage and its rate can be judged by watching the level of the gas bubble in the inner tube and the manometer

It is imperative that the first passage of gas should be very slow, as the sudden raising of pressure in the uterus is said to give rise to spasms around the uterine ends of the Fallopian tubes (*Kennedy*), and may give a negative result to the test

The reading of the gas pressure is watched on the manometer, and if the e of the gas is sufficiently slow, it will be seen to rise very gradually until

it comes to a point when it ceases to rise, and remains stationary or even falls a few millimetres *This is taken as an indication of the passage of gas through* the tubes The rate of the passage of the gas through the apparatus is then slowly accelerated, maintenance of a steady pressure as recorded by the manometer at the previous or even a slightly higher level is regarded as confirmation of the passage of gas through the tubes

If on the other hand the pressure shown on the manometer steadily rises up to 200 mm of mercury the passage of gas is stopped at that level the pressure is allowed to fall again to zero and the procedure is repeated

The raising of the intrauterine pressure to 200 mm of mercury on two successive occasions without the escape of gas is taken to indicate that the Fallopian tubes are not permeable

In those cases in which the manometric readings indicate the passage of gas, the latter is allowed to run through for a minute or two in order to collect sufficiently in the peritoneal cavity to give clinical and fluoroscopic X ray signs The same day (or the next day if the procedure has been carried out *under general anæsthesia) an X ray film of the diaphragmatic area is taken* with the patient in an upright posture when the exhibition of gas as a trans *lucent area under the diaphragm (i e between the diaphragm and the liver)* establishes the diagnosis of patency of one or both Fallopian tubes Where only a small amount of gas has entered the peritoneal cavity the translucent area may only appear as a thin triangle above the middle of the liver Where a large amount has entered the diaphragm and liver may be seen separated by a wide translucent area extending transversely across the whole width of the abdomen (Fig 253) The presence of even the smallest amount of free gas in the peritoneal cavity as seen between the diaphragm and liver is conclusive evidence of patency of one or both Fallopian tubes

The absence of gas in this area is strong presumptive evidence of occlusion of both tubes In such a case confirmation should be sought by injection of iodised oil into the uterine cavity (see uterosalpingography) as occasionally patency of one or both tubes may be demonstrated by uterosalpingography in a case where the findings by transuterine inflation were negative

PERITONEAL GAS INFLATION THROUGH THE ABDOMINAL WALL

In gynæcological conditions this method may be employed in cases where it is inadvisable to inflate *per uterum* particularly in pregnancy and in inflammatory conditions of the Fallopian tubes It is of value sometimes in those cases *where it is difficult to differentiate swellings of the tubes or ovaries* from the uterus

Technique—*There are certain technical difficulties to* be overcome which are not present with the other method The patient must be X rayed in the *Trendelenburg position in order to ensure that the gas in the* peritoneal cavity flows into the pelvic cavity around the pelvic organs and that the intestines as

far as possible slide into the upper abdomen. This entails incorporating a Potter Bucky diaphragm with a table capable of giving a good Trendelenburg position.

The patient requires careful preparation with regard to emptying the bowel and bladder, the latter being attended to just before the procedure.

To inject the gas into the peritoneal cavity, the Provis instrument is used

Fig. 253. Free gas in peritoneal cavity between diaphragm and liver

supplied with a sharp hollow needle at least 3 inches in length, instead of the uterine cannula used in the transuterine inflation.

For the sake of comparison a film is taken of the patient in the Trendelenburg position before injection of gas.

The needle is inserted, with antiseptic and aseptic precautions, through the abdominal wall 1 inch below and 1 inch to the left of the umbilicus. Local anaesthesia to the skin is unnecessary. The most painful point is the passage of the needle through the peritoneum.

Before inserting the needle the gas is very slowly turned on to show 2 3 mm of mercury pressure. As the needle is pushed steadily through the abdominal wall the pressure is seen to rise a few millimetres and to fall rapidly again when the needle penetrates the peritoneum. This is not only a reliable indication of the entrance of the needle into the peritoneal cavity but [illegible] will tend to prevent perforation of the intestines. Passing

the needle through the abdominal wall is safe and easy, however, without this manœuvre.

After the initial perforation of the skin, the needle is steadily pushed directly in, and the overcoming of two slight resistances can be felt, the first resistance being due to the anterior fascial sheath of the rectus muscle and the second to the posterior layer, with which is incorporated (except in the very

Fig. 254.—Shadow of enlarged uterus surrounded by translucent free gas in peritoneal cavity. (Trendelenburg position.)

obese) the peritoneum. When the point of the needle is in the peritoneal cavity, the flow of gas is increased through it, with due regard to the pressure recorded by the manometer, which should not read more than 50 mm. pressure.

The writers have not used a flow meter, being guided by the visible distension of the abdomen and by the sensations of the patient.

Films are then taken with the patient in the Trendelenburg position, both prone and supine (Fig. 254).

Diagnostic Applications.—In the diagnosis of pelvic conditions, *Jarcho* states that "the field for pneumoperitoneum is somewhat limited, as it is generally reserved for cases in which pelvic infection exists or in which the Fallopian tubes are occluded, making the production of pneumoperitoneum by the peruterine route unsafe or impossible. Under these conditions in obscure

cases, the injection of gas by puncture of the abdominal wall may prove of assistance in the diagnosis of *myomata fibroids, salpingitis, cystic* and *ovarian tumours* and in the location of *adhesions* involving the pelvic structures It may thus clarify the situation before operation is undertaken and by accurately locating the lesion may limit and simplify the surgical procedure '

INJECTION OF OPAQUE FLUID (UTEROSALPINGOGRAPHY)

The injection of a fluid opaque to X rays followed the method devised by *Rubin* of inflation of the uterus and Fallopian tubes by gas By many authorities it is claimed that it is superior to inflation with gas in that it shows

(1) The outline of the uterine cavity

(2) The length shape and disposition of the tubes

(3) The patency of one or both tubes

(4) If either tube is obstructed the site of obstruction

(5) When used with an initial peritoneal inflation the relationship of the uterus and tubes to a neoplasm

Owing to the fact that when the tubes are patent, part of the fluid is retained in the peritoneal cavity it is necessary that the medium shall be non toxic For this reason lipiodol or iodipin is used These substances are opaque to X rays are non toxic and are gradually absorbed when retained in the tubes and peritoneal cavity without any ill effects

If however the distal end of the tube be occluded or if the oil passes into a pocket or pockets due to peritoneal adhesions it may become encysted and be removable only by operative interference

Contraindications —The same contraindications apply to uterosalpingography as are enumerated under transuterine inflation by air

Technique —In this case it is necessary to make the injection of the fluid, viz lipiodol, with the patient in the lithotomy position on the Potter Bucky table The writers have not used any special apparatus beyond a 10 c c Record syringe fitted on the end of a Rubin s cannula A special apparatus has been designed similar to that for injection of gas, by which the pressure as well as the volume may be estimated

The patient s buttocks are brought to the end of the table, and a speculum is inserted into the vagina The cervix is grasped with volsellum forceps and after swabbing a sound is inserted to give the length and direction of the cavity of the uterus The cannula is then inserted and volsella are refixed to try to form a snug fluid tight joint between the cervix and the rubber acorn on the tube

The patient is then moved back into position over the Potter Bucky diaphragm carefully without displacing the tube in the uterus the legs being gently lowered so that the patient lies supine with the legs extended

The film is then put in the carrier and all preparations are made for taking the radiogram before the injection is started The writers have not made a

practice of watching the injection with a fluorescent screen but aim at taking the first radiogram when the cavity of the uterus is distended The patient is specially warned not to move but to cry "Oh!" when she feels any pain She has discomfort with the presence of the tube in the uterus, but as the oil is

FIG 255—Uterosalpingography after injection of 4 c c lipiodol into uterus

slowly injected to fill the uterus it causes pain, and her cry is the signal to take the radiogram (Fig 255) (or preferably a pair of stereoscopic radiograms) The amount necessary to achieve this varies in different subjects but is usually about 3–4 c c

The exposed film is removed and replaced by another one without removal of the cannula and a further film (Fig 206) is taken after the injection of 1 2 c c more oil Subsequent films may be taken to eliminate narrowing of the lumen of the tubes due to physiological contraction (Leakage of oil back

Fig 206 —Same patient as Fig 205 after injection of 6 c c lipiodol into uterus

through the cervix is very apt to occur and to spoil the pictures if the series of radiograms is not taken quickly)

In the radiograms the outline of the uterine cavity is readily seen that of the tubes depends on the conditions present

Diagnostic Applications —In the case of *normal tubes* (Fig 257) lipiodol is seen in the majority of cases to be present *in small drops in the* pouch of Douglas or in the neighbourhood of the fimbrial ends In *occlusion of the fimbrial end* there may be shown a bulbous outline according to the condition of the tube with absence of *drops in the peritoneal* cavity In *occlusion of the uterine end* there is of course no lipiodol in the tube and consequently no shadow on *the affected side* (Fig 258) When the tubes become filled with lipiodol their shape length and disposition are readily disclosed whether *patent into the peritoneum* or not

It is strongly recommended that further films be taken after twenty four and forty-eight hours in order to confirm in a positive case or substantiate or negative in a doubtful case the passage of oil through the tube In the case of *patency of one or both tubes* these later radiograms will show the presence of lipiodol in streaks (Fig 259) resembling *ripples* of sand on the seashore in the cavity of the pelvis This is caused by the lipiodol draining out of the tubes into the pelvis where it spreads out between

Fig Utero-salpingogram Normal Fallopian tubes Droplets in pouch of Douglas

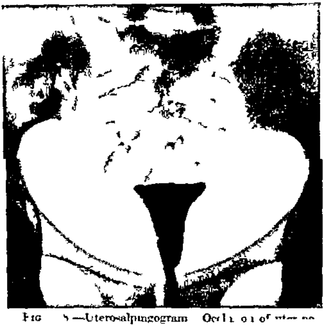

Fig —Utero-salpingogram Occlusion of uterine ends of both tubes

the coils of bowel, that in the uterus drains out of the cervix into the vagina and is usually not seen in the later radiograms Emphasis should be placed on the necessity for taking a radiogram on the day following the injection, as not infrequently lipiodol is then found in the peritoneal cavity (Fig 261) in cases in which from the earlier radiograms the tubes appear to be occluded (Fig 260) The non passage of the lipiodol through the fimbriated

Fig 259 —Utero-salpingogram Same patient as Fig 255 Radiogram 24 hours after injection of lipiodol into uterus Note wavy shadows of lipiodol in peritoneal cavity

ends of the Fallopian tubes at the time of the injection is presumably due to spasm which later relaxes and allows the lipiodol to pass into the peritoneal cavity giving rise to the characteristic wave like shadows referred to

Droplets of oil seen *outside* the tube indicate patency of the tube but if in the later radiograms (next day) they have failed to spread out to form the characteristic wave like shadows indicative of free lipiodol in the peritoneal cavity the possibility of a walled in peritoneal pocket must be

FIG 260 — Apparently closed tubes See radiogram taken next day

FIG 261 — Same patient as Fig 260 Radiogram taken next day showing lipiodol in peritoneal cavity

considered (Fig 262) Droplets of oil *inside* a dilated tube will indicate the presence of *hydrosalpinx*

The presence of a *bicornuate uterus* (Fig 263) is readily demonstrated by uterosalpingography with iodised oil

Anteflexion and *retroflexion* are best demonstrated in lateral radiograms after injection of iodised oil

In the event of the uterine cavity showing a filling defect or defects the presence of *interstitial* or *submucous fibroids* or of *carcinoma uteri* is suggested

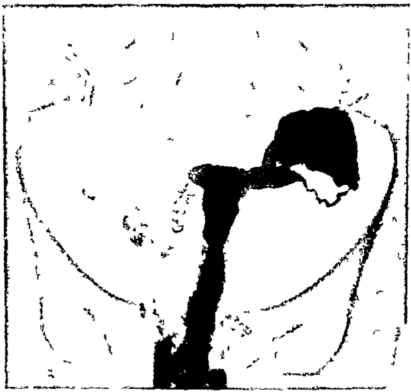

Fig 262 Uterosalpingogram oil in walled in peritoneal pocket

In the case of fibroids the filling-defect is usually smooth while in carcinoma it is more likely to be ragged in contour

If a small polyp or submucous fibroid be present, especially on the anterior or posterior wall it may be obscured if the uterus be distended by lipiodol For this reason a radiogram is advisable before the uterus is fully distended

Where possible a control of the degree of filling is advisable by fluoroscopy, though the writers have not done this as a routine

The differential diagnosis of an *early pregnancy* from a *single fibroid* is often

one of difficulty. According to *Hernstein* failure of the oil to enter the Fallopian tubes in such a case is a point in favour of pregnancy. He states that early closure of the cornua is the rule in pregnancy irrespective of the site of attachment of the ovum.

Fig. 263 —Utero-salpingogram showing bicornuate uterus. One tube is filled. Note filling defects due to submucous fibroids.

It should be noted however that fibroids in the region of the cornua may prevent filling of one or both tubes.

Where an *ectopic pregnancy* is suspected and the diagnosis cannot be established either by clinical means or by direct radiography uterosalpingography may be of value. If it is found that both tubes are permeable ectopic pregnancy may be excluded. If one tube be permeable and the other dilated and

partly or completely obstructed, with a flat or rounded filling defect at the obstructed end, an *ectopic pregnancy* should be suspected

In the case of extrauterine tumours, such as *ovarian* or *intraligamentous cysts* or *dermoids* or of *pedunculated fibromata*, the uterine shadow will show a displacement laterally or antero posteriorly away from the tumour, the shadow of the uterine cavity being otherwise normal The Fallopian tube also will

Fig 264 —Extrauterine tumour (ovarian cyst) causing displacement of the uterus and Fallopian tubes towards the opposite side The palpable tumour limits are marked by a wire on the abdomen

show elongation and displacement by the tumour (Fig 264), over which it may be stretched

If there is doubt as to the relationship to the uterus of a fœtus shown by direct radiography, the question can be settled by demonstrating the position and shape of the uterine cavity by uterosalpingography Such a procedure should not be adopted however, unless the termination of the pregnancy is in any case desirable (Fig 265)

COMBINATION OF PERITONEAL INFLATION AND PER TUBAL INJECTION WITH LIPIODOL

The writers have no experience of this method It is recommended by *Stein* and *Arens* particularly in cases of a tumour or tumours in the pelvis, in which it is required to differentiate the uterus and tubes

The peritoneum must be inflated with gas first, the lipiodol is then injected and the film taken with the patient in the Trendelenburg position, as in a simple gas inflation

According to *Jarcho* (who shows several illustrative radiograms) the *combination* of the two methods is indicated when additional information, not obtainable by either method alone, is desired When *successful*, it enables the clinician to map out normal and abnormal states of the pelvic viscera *Frequently neoplasms of the* uterus and adnexa are clearly demonstrated The method also shows distinctly the sphincters at the proximal end of the interstitial portion of the Fallopian tubes

FIG 2b5 —Lipiodol injected into uterus Angular pregnancy

Its maximum utility appears to be in the visualisation of *uterine fibroids* and of *ovarian cysts*, their relation to the uterine cavity being clearly demonstrated

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PART FIVE

OBSTETRICS

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PART FIVE

OBSTETRICS

CHAPTER XXXI

GENERAL TECHNIQUE

THE EVOLUTION of radiology in obstetrics has been comparatively slow In earlier times workers were handicapped by limitations in the power of apparatus it being impossible to produce currents of sufficient intensity and kilovoltage to penetrate satisfactorily the relatively opaque liquor amnii and to cut down the length of the exposure to a degree in which the motility of the fœtus and the respiratory movements of the mother could be eliminated Nowadays however with apparatus having a large output of energy hot cathode tubes capable of carrying large currents the Potter Bucky diaphragm by which secondary radiations are largely eliminated immobilising appliances and ultra rapid films and intensifying screens the technical difficulties encountered by earlier workers have to a great extent disappeared Satisfactory radiograms *of the gravid uterus can now be obtained readily in from two to six seconds*

TECHNIQUE OF EXAMINATION

Even with the most efficient apparatus special attention must be paid to technique if uniformly satisfactory radiograms are to be obtained

Apparatus and Accessories —A modern high tension transformer should be used with a hot cathode tube an efficient Potter Bucky diaphragm fitted with a *compressor band and rapid speed double coated films and intensifying screens*

Kilovoltage —The quality of X rays used must be such that they will penetrate the opaque liquor amnii but will not over penetrate the developing fœtal bony parts In the earlier stages of pregnancy and when the patient is thin and there is no excess of liquor amnii a kilovoltage of 60 to 65 K V P will be sufficient In the later stages of pregnancy or when the patient s girth is large (especially if this be due to hydramnios) kilovoltages up to 100 K V P may be necessary *A filter of 1–2 mm aluminium below the X ray tube is advisable*

Current —A current of 50 M A or upwards should be employed in order to cut down the time of exposure to a minimum

Focus film Distance —If the distance between the target of the X ray tube and the film be small the exposure will be cut down but owing to the divergence of the rays there will be produced on the film a lack of definition and a disproportion between the fœtal and maternal parts which may be misleading

If the focus film distance be great the disproportion will be less but the time of exposure will need to be increased to a degree when fœtal and maternal movements may occur with resultant blurring of the image

A routine working distance of 30 inches between the target and film is therefore recommended as a satisfactory compromise Whatever working distance be decided upon it is advisable to keep it constant for all cases in order that the resultant radiographic sizes may be comparable

Exposure—This will depend on the milliamperage used the speed of the films and intensifying screens and the distance of the tube from the film together with the thickness of the part to be radiographed

The shorter the exposure the less risk is there of the film being spoilt by fœtal or maternal movements With suitable apparatus and accessories satisfactory radiograms at a focus film distance of 30 inches should be obtained in a patient of moderate size in about two seconds in no case should the exposure exceed six seconds—otherwise blurring of the fœtal or maternal movement is practically inevitable (this does not of course apply to pelvimetry where the fœtal image is of secondary importance)

Position of Patient—It is usually advisable to take radiograms in the supine prone and lateral positions (right or left according to the position of the fœtus) Occasionally an oblique view is advisable to throw the shadow of the fœtal bony parts away from the maternal skeletal shadows

In the prone position it may be desirable in some cases to relieve the pressure on the abdomen by supporting the thighs on a pillow if necessary also the patient may be allowed to rest the thorax firmly on the elbows with the arms crossed under the chest but out of the way of the abdomen The chief advantages of the prone position are that this position in most cases brings the fœtus nearer the film and also immobilises it better resulting in clearer definition of the fœtal parts

The advantages of the lateral view are that it gives information relating to the position of the fœtal spine (anterior or posterior) and that the fœtal limb shadows are more likely to be shown clear of those of the maternal spine On this account ossific centres in the fœtus can often be shown more readily in this position than in the prone or supine position Lateral radiograms in the erect position are of special value in patients with pendulous abdomens where information is required regarding the inclination of the pelvic brim to the axis of the lumbar spine —in such examinations a vertical Potter Bucky diaphragm is of course required

The lateral view centred over the brim of the pelvis also gives valuable information as to the plane of the brim the lumbo sacral angle the shape and plane of the anterior surface of the sacrum the inclination of the posterior surface of the symphysis pubis and the relation of the fœtal head to the superior strait of the pelvis It also gives a ready means of confirming the measurement of the conjugate diameter of the brim as estimated by other pelvimetric methods (see later)

In the supine position especially if there be lordosis it is often helpful to put a pillow beneath the knees of the patient this gives a greater sense of comfort to the mother and brings her spine nearer to the film by flattening out the lumbar curve

Immobilisation of the Fœtus —This is helped by the use of a compressor band the latter should however not be pulled too tightly otherwise increased fœtal activity instead of immobilisation will be the result

Suppression of Maternal Respiratory Movement —Owing to the presence in the abdomen of the enlarged uterus the pregnant woman finds it more difficult to hold her breath than the non pregnant patient It is however essential *that during the exposure there shall be no respiratory movement* *The readiest* means of bringing this about is to make the patient after a few preliminary respirations hold her nose and close her lips at the point of deep expiration After a *little* practice most patients can by this means be persuaded to suppress their respiration for the requisite period of time during the making of the exposure Obviously the shorter the exposure the better the result in this respect Experience shows that there is a better chance of complete immobility on the part of the diaphragm in expiration than in inspiration

A series of at least three radiograms (supine prone and lateral) now having been taken our next consideration is the information that may be obtained from them

INFORMATION AVAILABLE FROM RADIOGRAPHIC EXAMINATION

Information on the following points may be available from an inspection of the radiograms

(1) The positive diagnosis of pregnancy or in a case of an obscure swelling the differential diagnosis between pregnancy and a pelvic tumour

(2) The *presence or absence of any gross* maternal deformity (lesser degrees of deformity are demonstrable by means of radiological pelvimetry to be described later)

(3) The *approximate indication of the age of the fœtus*

(4) The position and presentation of the fœtus the position of its limbs *and the degree of flexion of its spine and head*

(5) The existence or otherwise of *any disproportion between the fœtal* head and the maternal pelvis

(6) The cause of hydramnios with special reference to multiple pregnancy and fœtal abnormalities

(7) Intrauterine death of the fœtus

(8) Occasionally evidence of extrauterine pregnancy

CHAPTER XXXII

DIAGNOSIS OF PREGNANCY AND MATERNAL PELVIC DEFORMITIES

X-RAY DIAGNOSIS OF PREGNANCY

SINCE THE advent of the Zondek Ascheim test the early diagnosis of pregnancy by radiology is of less importance than previously

The radiological diagnosis is however an immediate one, whereas the Zondek Ascheim test takes a few days for its completion The radiological examination is particularly applicable in cases of suspected illegitimate pregnancy where obvious difficulties may arise in performing a clinical examination

Diagnosis by Direct Radiography—Owing to the relatively poor calcium content of the fœtal skeleton in the early stages of pregnancy, it is not possible, even with the most careful technique to demonstrate fœtal bony parts before the thirteenth week As a rule consistent demonstration of fœtal parts is not possible till about the sixteenth to twentieth week The film must be of good quality and the shadows of the maternal bony parts dislodged from the uterine area as much as possible For this purpose the prone position may be used with the tube tilted slightly towards the head or the supine position with the tube tilted slightly towards the feet Sometimes a slightly oblique position of the mother s pelvis in relation to the central ray is also of advantage

In the pelvic area the shadows to be searched for are one or more of the following (Figs 266 267)

(*a*) The crescentic or annular shadows of the fœtal skull

(*b*) The beaded shadow of the fœtal spine

(*c*) The ladder like shadow of the fœtal ribs

(*d*) The linear shadow of one or more of the fœtal limb bones

Before excluding the presence of a fœtus at least three good radiograms should give negative results In cases of doubt the examination should be repeated after an interval of one or two weeks Care should of course, be taken to eliminate rectal or vesical shadows by efficient preliminary preparation

At or after the sixteenth week it should be possible to exclude pregnancy definitely by radiographic means The differential diagnosis of pregnancy from *hydatidiform mole uterine* or *other pelvic tumours* should be thus rendered definite

Diagnosis by the Use of Contrast Media—By injecting lipiodol into the uterine cavity *Heuser* had been able to demonstrate as early as one week after conception the presence of the ovum as a filling defect in the opaque medium The employment of this method however is indicated only in cases where a

termination of pregnancy if present would be desirable there is a grave risk of the oil, when injected into the uterine cavity producing abortion A submucous polyp if present might produce a filling-defect which would be indistinguishable from that of an ovum

By the method of transabdominal pneumoperitoneum *Peterson* has been able

Fig ?66 —Thirteen weeks fœtus showing limb bones spine and ribs

to diagnose uterine enlargement indicative of pregnancy as early as the sixth week

However *Hernstein* states that in cases of pregnancy the cornua close early so that a rounded filling defect in the uterine cavity combined with non filling of the Fallopian tubes is presumptive evidence of pregnancy rather than of fibroids (see p 377)

Albano claims to have demonstrated by intravenous injection of 2 grms of strontium bromide in a 10 per cent solution half an hour before radiography, a two months pregnancy as a relatively translucent area in the liquor amnii (which has been made more opaque by excretion of the dye) He also claims to be able to differentiate between pregnancy and a uterine fibroid by this

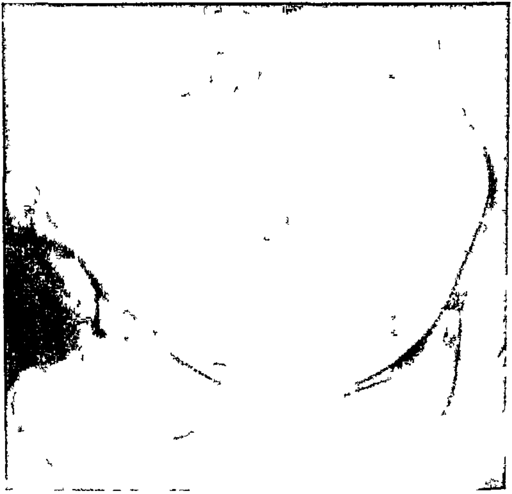


Fig 267 —Sixteen weeks fœtus showing skull ribs and limb bones

method the uterus in pregnancy showing a clear-cut outline as opposed to the fluffy shadow of fibroids His work however lacks confirmation

CHANGES IN THE PELVIC JOINTS DURING PREGNANCY

During pregnancy the symphysis pubis and to a less extent the sacro iliac joints increase in width By applying the appropriate correction factors

to compensate for the distance of these joints from the film Roberts estimat the true width of the symphysis pubis and sacro iliac joints in the series pregnant and non pregnant women He found the average "mean" width the symphysis pubis in nulliparous women to be 2 6 mm , during pregnan *this increased to 4 5 mm During parturition he found that any further increa* in width was very slight and that within a few months after parturition t width usually returned to its pre pregnant measurement In multiparo women the increase in width during pregnancy was slightly greater than *primigravidæ*, the average *width in pregnant multiparæ* being 5 mm

FIG 268 —*Dislocation of symphysis pubis following difficult labour*

opposed to the primigravidous average width of 4 5 mm The maximu width seen in his series was 10 mm

In pregnant cases with a wide symphysis he was able to demonstrat radiologically a vertical or gliding movement of the pubic bones on each othe when the weight of the body was transferred from one foot to the other

The sacro iliac joint likewise widens slightly during pregnancy Th average aggregate width of the two sacro iliac joints in nulliparous women wa found to be 3 6 mm In primigravidæ it increased to 4 5 mm , while the sam measurement was recorded for multiparæ After parturition the averag width of the joints was found to return to 3 9 mm , i e almost, but not quite, t its pre pregnant width

As a result of difficult labour with or without the application of forceps traumatic rupture or dislocation of the symphysis pubis sometimes occurs (Fig 268) Occasionally fractures through the pubic and ischial rami may occur

Normally however the fœtal skull gives way to the pressure more readily than the firmer maternal bony pelvis with the result that radiograms taken during parturition show a greater or less degree of moulding of the bones of the vault which may override each other to a marked degree (Fig 302)

MATERNAL PELVIC DEFORMITIES

Gross pelvic deformities will be usually demonstrated in a single radiogram in the supine position amplified where necessary by stereoscopic radiograms in either the supine or prone position and/or by a lateral view Minor deformities however may need a more accurate investigation by means of radiological pelvimetry

Any deformity of the maternal spine or pelvis which may give rise to difficult labour is of importance to the obstetrical radiologist As however the X ray appearances associated with the various conditions which may result in such deformities have been described elsewhere in this book no useful purpose will be served by their reiteration It may however be of service to the radiologist if their obstetrical classification be recalled at this juncture The following classification by *Schauta* modified by *Dougal* will probably be found the most suitable

A CONGENITAL ABNORMALITIES

(*a*) Generally contracted pelvis
(*b*) Simple flat pelvis
(*c*) Assimilation pelvis
(*d*) Nægele pelvis
(*e*) Roberts pelvis
(*f*) Generally enlarged pelvis
(*g*) Split pelvis

B ACQUIRED ABNORMALITIES

(1) *Disease or Injury of the Pelvic Bones*
(*a*) Rickets (i) Rachitic flat pelvis
(ii) Rachitic flat and generally contracted pelvis
(iii) Irregularly contracted rachitic pelvis
(*b*) Osteomalacia—osteomalacic pelvis
(*c*) New growths
(*d*) Fracture
(*e*) Atrophy caries necrosis

(2) *Disease or Injury of the Pelvic Joints*

- (*a*) Synostosis of the pelvic symphysis
- (*b*) Synostosis of one or both sacro iliac joints
- (*c*) Synostosis of sacro coccygeal joint
- (*d*) Exaggerated movement or separation of pelvic joints

(3) *Disease or Injury of the Vertebræ*

- (*a*) Scoliosis
- (*b*) Kyphosis
- (*c*) Kypo scoliosis
- (*d*) Lordosis
- (*e*) Spondylolisthesis

(4) *Disease or Injury of the Hip Joints or Lower Limbs*

- (*a*) Coxitis
- (*b*) Luxation of the head of one or both femora
- (*c*) Absence or deformity of one or both lower extremities

CHAPTER XXXIII

RADIOLOGICAL PELVIMETRY

Whilst cordially agreeing with the axiom that "the best pelvimeter is the fœtal head" one finds that obstetricians are not infrequently faced with cases in which the relative size of the fœtal head and of the pelvic inlet cannot be gauged by clinical means. In such cases radiology may be called on to play an important part in accurately assessing the diameters of the pelvic brim or of the outlet.

It is obvious that the less tissue the X rays have to penetrate (i e the earlier in the pregnancy) the clearer will be the radiograms; unfortunately the patient is often allowed to go almost to full term before the radiologist is asked to investigate her pelvic measurements.

RADIOLOGICAL PELVIMETRY OF THE INLET

Among the methods more commonly employed in this country for estimating the diameters of the brim by radiological means may be mentioned the following:

Methods of Thoms, Roberts and Rowden.—In each of these methods the brim of the pelvis is placed horizontally and parallel to the X ray film and the central X ray is made to pass vertically through its centre; the radiogram so obtained is a symmetrically enlarged picture of the pelvic brim (Fig. 269) without any of the foreshortening seen in the usual supine or prone radiograms.

Technique of Thoms' Method of Pelvimetry.—The patient is placed in the sitting position (originally described by *Albert*) on the middle of the Potter Bucky diaphragm, her shoulders being supported by an adjustable back rest. The patient and back rest are manipulated till the pelvic brim is horizontal, i e parallel to the film on the Potter Bucky tray. This is attained by means of a calliper, one foot of which is placed in contact with the upper border of the symphysis pubis while the other foot is placed in contact with the lower border of the spine of the fourth lumbar vertebra (the latter point is situated about an inch above the line joining the posterior superior spines of the iliac bones felt in dimples on each side of the middle line).

The patient having been placed centrally over the film in this position and leaning firmly against the back rest (which will be about 55°–60° from the horizontal) the X ray tube is placed so that its focal spot is vertically above the middle of the pelvic brim (approximately 2 inches behind the upper border

of the symphysis pubis) The tube is then raised or lowered till its target is 30 inches vertically above the film

The radiogram is now taken and the vertical height of the upper border of the symphysis (corresponding to the horizontal plane of the pelvic brim) is measured The patient is now removed from the table the tube and film being left in position

A perforated metal sheet (in which small holes have been punched at the points of intersection of lines drawn at right angles 1 cm apart) is now substituted at the height previously occupied by the patient s pelvic brim and a

Fig 269 —Radiogram in sitting position with pelvic brim placed horizontally

short exposure of one to two seconds is made The perforations in the metal sheet show on the film as black dots these dots on the film are slightly more than 1 cm apart according to the height of the sheet above the film The length of the diameters can now be measured directly on the film (in centimetres) from this false centimetre scale produced by the dots

Technique of Roberts' Method of Pelvimetry—In this method the position of the patient tube and film are as in *Thoms* method (i e the patient sits on the Potter Bucky diaphragm with the pelvic brim horizontal her back being supported by an adjustable back rest and her head kept extended so as to be at a safe distance from the tube the tube being rotated so that its projecting arms are across the long axis of the table The tube is centred 30 inches vertically above the centre of the brim (2 inches behind the vertical plane of the symphysis—estimated more accurately if desired, by means of a plumb

bob—hanging down beneath the centre of the filter in the diaphragm of the tube box) (Fig 270)

The radiogram is now taken, an exposure of five to twelve seconds is usually sufficient with an efficient apparatus (10 K.V.A transformer, hot-cathode tube passing 50 M A at 100 to 120 K V P), this exposure may need to be increased in a bulky or advancedly pregnant patient

A radiogram of more even density is obtained if the "hatchet" described

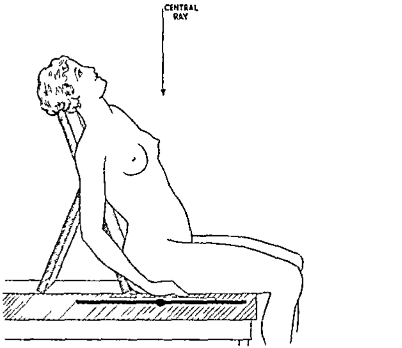


Fig 270—Position of patient in Roberts method of radiological pelvimetry By this means the pelvic brim is brought parallel to the film and an undistorted uniformly enlarged representation of the brim is obtained From the radiogram all the diameters may be readily and accurately estimated

in *Rowden's* method (see later) is employed, this prevents the relative over exposure of the anterior portion of the brim which otherwise takes place

Immediately after the radiogram has been taken and without moving the patient the following measurements are made

(1) The vertical height of the anticathode above the upper border of the symphysis pubis (by a tape measure) or alternatively the vertical height of the top of the symphysis above the film (by ruler)

(Instead of measuring the tube symphysis distance it will probably be found easier to measure the symphysis film height The simplest way of doing this is to use an ordinary wooden ruler from the bottom of which a

length has been chopped off equal to the vertical distance between the surface of the middle of the Potter Bucky table and the film. This distance is readily measured by placing a strong lath transversely across the top of the table and measuring the vertical height of this above the middle of the table and above the film respectively, the difference between these two measurements is the distance between the film and the top of the table and is the amount which must be chopped off from the end of the ruler. It must be measured accurately, otherwise an error will be introduced into all future estimates of pelvic measurements based on this technique. In the curved topped Potter Bucky table used by the author it is $1\frac{1}{4}$ inches. It will vary with different tables and different types of cassettes.)

(2) The vertical height of the anticathode above the film (a standard tube film height of 30 inches is suitable, with suitable apparatus this may with advantage be increased to 40 inches)

It is easy to estimate the true diameters of the pelvic brim from those on the film by employing the geometric principle illustrated in Fig. 271.

To obviate the necessity for these geometrical calculations tables have been prepared from which one can obtain at a glance the corrected or true measurement of any diameter from the corresponding film measurement (Tables 1 and 2).

Thus if when using the 30 inch tube film distance the tube symphysis height be $24\frac{1}{2}$ inches (i.e. symphysis film height $5\frac{1}{2}$ inches) and the measurement on the film of the transverse diameter be say $6\frac{1}{4}$ inches, then the true measurement of the transverse diameter is seen from the table to be 5.1 inches. Similarly for any other measurement.

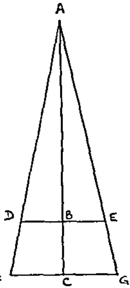


Fig. 271

A = target of tube
DE = required diameter of pelvic brim
FG = corresponding diameter of brim as measured on film
AB = height of tube above symphysis pubis
AC = height of tube above film

$$\frac{DE}{FG} = \frac{AB}{AC}$$

$$DE = FG \times \frac{AB}{AC}$$

i.e. True diameter = film diameter multiplied by correction factor $\left(\frac{AB}{AC}\right)$

Similar tables may be prepared for any tube film distance other than the standards used here. Obviously, the greater the tube film distance, the smaller the margin of error. Many workers are, however, limited in their working distance, either by the output of their plant or by the type of Potter-Bucky table available.

Estimation of the Measurement of the Conjugate from Lateral View of Pelvis.—In the event of a patient having spinal or hip disease, it may be impossible so to posture the patient that the pelvic brim is parallel to the film, or

RADIOLOGICAL PELVIMETRY CORRECTION TABLES

TABLE 1.—WHERE TUBE FILM HEIGHT = 30 INCHES

Measurement on Film	True or Corrected Measurement.			
4 inches	3.2	3.3	3.3	3.4 inches
4¼	3.4	3.5	3.5	3.6
4½	3.6	3.7	3.7	3.8
4¾	3.8	3.9	3.9	4.0
5	4.0	4.1	4.1	4.2
5¼	4.2	4.3	4.4	4.5
5½	4.4	4.5	4.6	4.7
5¾	4.6	4.7	4.8	4.9
6	4.8	4.9	5.0	5.1
6¼	5.0	5.1	5.2	5.3
6½	5.2	5.3	5.4	5.5
6¾	5.4	5.5	5.6	5.7
Tube symphysis height (inches)	24	24½	25	25½
Symphysis film height (inches)	6	5½		4½

TABLE 2.—WHERE TUBE FILM HEIGHT = 40 INCHES

Measurement on Film	True or Corrected Measurement			
4 inches	3.4	3.4	3.5	3.5 inches
4¼	3.6	3.7	3.7	3.7
4½	3.8	3.9	4.0	4.0
4¾	4.0	4.1	4.2	4.2
5	[illegible]	4.3	4.4	4.4
5¼	4.5	4.5	4.6	4.7
5½	4.7	4.7	4.8	4.9
5¾	4.9	4.9	5.0	5.1
6	5.1	5.2	5.2	5.3
6¼	5.3	5.4	5.5	[illegible]
6½	[illegible]	5.6	5.7	5.8
6¾	5.7	5.8	5.9	6.0
Tube symphysis height (inches)	34	34½	35	35½
Symphysis film height (inches)	6	5½	[illegible]	4½

In an obese or otherwise unsatisfactory patient it may be desirable to confirm the conjugate measurement as estimated by the foregoing method In cases of pendulous abdomen or when the fœtal head overrides the symphysis pubis it may be difficult to measure the exact height of the symphysis above the film or below the tube

In such cases the measurement of the conjugate can be readily estimated from a lateral view of the pelvis The patient is placed lying accurately on

the side so that the conjugate diameter is horizontal (i e symphysis pubis at the same height as the natal cleft or more accurately the spinous process of the fourth lumbar vertebra)

The tube is centred vertically over the upper border of the greater trochanter at a height of 40 inches above the film The radiogram is taken and the vertical distance between the symphysis pubis and the target of the tube is measured (by a tape measure or ruler)

The conjugate diameter (distance between the posterior surface of the upper part of the symphysis and the anterior surface of the promontory) is measured on the film From this it is quite easy to estimate the true conjugate by employing the principle of Fig 271

Technique of Rowden's Method of Pelvimetry

In this the patient is placed in the same position in relation to the film as in *Thoms'* and *Roberts'* method (*Albert s* position) and the tube again centred vertically above the middle of the horizontally placed pelvic brim The tube film distance is however, greater than in *Thoms'* and *Roberts* methods, being 4 feet 6 inches, and a Sectogrid Potter Bucky diaphragm takes the place of the curved type The increased tube film distance diminishes the degree of distortion produced on the film

To prevent relative over-exposure of the anterior portion of the brim or under-exposure of its posterior portion *Rowden* advocates the use of a "hatchet" This is a sheet of lead on a wooden handle, the whole resembling a spade with the distal portion cut out into a slight concavity After the anterior portion of the brim has received about twelve seconds' exposure (15 M A at 120 K V P) this hatchet is placed horizontally against the patient's abdomen about the level of the umbilicus, the exposure of the posterior portion of the brim is continued for a further twelve to thirty seconds (according to the size of the patient's abdomen) By this means the resultant radiogram is rendered of more even density

In measuring the diameters, *Rowden* uses the appropriate one of a series of "pubic scales", these are prepared as follows

A strip of lead, called a "rule," is used, about 12 inches long and 2 inches wide, supported by plywood, the lead strip has small holes drilled down the centre exactly half an inch apart

From this "rule" the "pubic scales" (Fig 272) are made in the following way The "rule" is supported horizontally over the Potter Bucky couch 4¾ inches above the surface, a film in a cassette being placed in the usual position The X ray tube is centred 4 feet 6 inches above the film and a short exposure, about a second, given The "rule" is then raised a quarter of an inch and another exposure is made on another film, and so on every quarter of an inch up to 6 inches The films are developed and a number of prints are made from each for stock, and each has its distinctive figure of height marked on it The

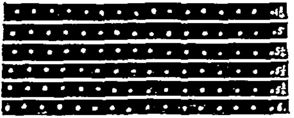


Fig 272 —Rowden's pubic scale

spots on the scales thus produced represent half inches at horizontal planes above the surface of the Bucky couch

Technique of Hooton's Method of Pelvimetry

In *Hooton's* method antero posterior and lateral films are taken with the tube centred $1\frac{1}{2}$ inches above the os pubis and just above the great trochanter respectively

The thickness of the patient from pubis to couch (a) and her extreme width across the trochanters (b) are then measured Let the focus film distance be 28 inches (c) On the antero posterior film the transverse diameter is measured (d) and on the lateral film the distance from the sacral promontory to the back of the os pubis (e)

The calculation is as follows

$$\frac{d \times (c - \frac{2}{3}a)}{c} = \text{true transverse diameter}$$

$$\frac{e \quad (c - \frac{1}{2}b)}{c} = \text{true conjugate diameter}$$

Technique of Courtney Gage's Method of Pelvimetry

In *Courtney Gage's* method the patient occupies the semi sitting position over the film the tube being centred over the middle of the pelvic inlet a plumb bob hanging from the centre of the filter and remaining in position during the exposure

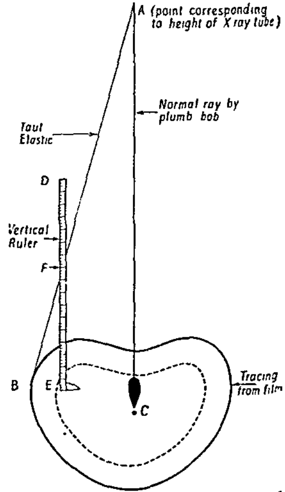


Fig 273 —Illustrating Courtney Gage's method of pelvimetry

of the film, thus records on the film the point of incidence of the normal or vertical ray

The distances of the tube and of the top of the symphysis pubis from the film are measured

After development, a tracing of the outline of the pelvic inlet is made from the dried radiogram, and a dot placed on the tracing at a point corresponding to the centre of the shadow of the plumb bob This tracing is pinned on to the table

By means of a taut piece of elastic (AB) a plumb bob (AC) and a vertical ruler (DE), used as in the illustration (Fig 273), the lines of the rays which have produced the image of the pelvic brim are reproduced, the lower end (B) of the elastic being moved round the tracing and the ruler being moved till the point on it (F) corresponding to the height of the symphysis pubis above the film intersects the elastic

By marking with a pencil dots on the tracing at points corresponding to the base of the ruler (E) and joining these dots an exact reproduction of the pelvic brim is obtained from which the various diameters are measured directly

RADIOLOGICAL MEASUREMENT OF THE PELVIC OUTLET

Transverse Diameter Chassard and Lapine's Method

The patient is placed straddling a cassette containing a 12" × 10" film, she is made to stoop forward till the under surface of the symphysis pubis and the ischial tuberosities are equidistant from the film i e the pubic arch is now horizontal The tube is centred vertically above or slightly posterior to the ischial tuberosities at a distance of 30 inches or more from the film (Fig 274)

A radiogram is now taken (about one to one and a half seconds will suffice with 30 M A at 75 K V P) On the radiogram (Fig 275) a horizontal line is drawn to touch the surfaces of the ischial

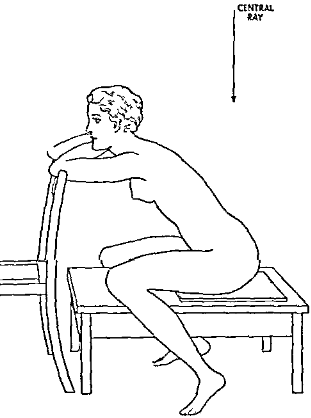


Fig 274—Position of patient film and tube in Chassard and Lapine's method of pelvimetry of outlet

tuberosities A vertical line is drawn from the symphysis pubis to bisect this A second horizontal line is now drawn 1 cm nearer the symphysis pubis than the first one (to compensate for enlargement due to distance of bony parts from the film) The length of this line is approximately the measurement of the transverse diameter of the outlet (normally 4 inches)

From this radiogram there can also be determined by direct measurement

(1) The angle of the pubic arch (normally 83°)

(2) The height or depth of the pubic arch (normally about 2½ inches)

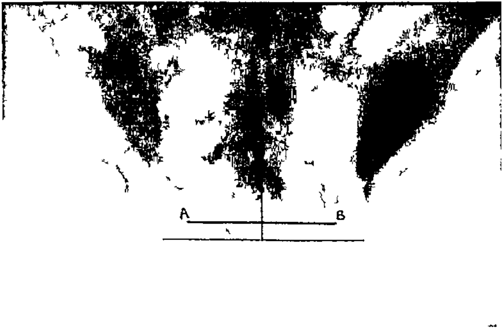


FIG 275—Radiogram of pelvic outlet by Chassard and Lapiné's method AB = transverse diameter of outlet (see text)

Antero-posterior Diameter of the Outlet (Posterior Portion)

Any forward tilting of the sacrum or coccyx will diminish the antero posterior diameter of the outlet

TECHNIQUE —On the Potter Bucky diaphragm the patient lies on her side and the tube is centred vertically above the ischial tuberosities (the position of the patient being adjusted till these are above the centre of the film) A radiogram is now taken

The vertical distance of the tube from the film and from the natal cleft is measured by a tape measure and the appropriate correction factor is estimated The film measurement of the distance between the back of the ischial tuberosities and the tip of the coccyx multiplied by this correction factor, is the true measurement of the posterior part of the antero posterior diameter of the outlet

CHAPTER XXXIV

CEPHALOMETRY

THOMS' METHOD OF CEPHALOMETRY

THE PRINCIPLES involved in radiological pelvimetry can be employed in favourable cases for an estimation of the size of the head of the full term fœtus *in utero* The patient is placed in the supine position on the Potter-Bucky diaphragm The fœtal skull is then orientated by abdominal palpation, the height of its occipito frontal diameter above the film is measured by means of callipers, and the inclination of the plane of this diameter to the horizontal is noted A radiogram is then taken, with the tube centred at a measured height above the film, over the middle of the fœtal skull With the tube and film still in position the patient is removed and a lead plate with perforations 1 cm apart is introduced in the same plane as that previously occupied by the occipito frontal diameter, and a further exposure made on the same film On the film the space between the perforations will be enlarged in the same pro portion as the occipito frontal diameter The measurement of the latter can therefore be directly obtained from the slightly magnified centimetre scale formed by the perforation dots on the film

From an extrauterine study of 149 fœtal heads which had not been sub jected to moulding, *Thoms* constructed a table showing the relation of the occipito-frontal diameter to the biparietal diameter This is given herewith

Given an occipito frontal diameter of

12 5 cm	subtract	2 5	cm	for	biparietal	diameter
12 0	„	„	2 5	„	„	„	„
11 5	„	„	2 0	„	„	„	„
11 0	„	„	1 75	„	„	„	„
10 5	„	„	1 5	„	„	„	„
10 0	„	„	1 5	„	„	„	„
9 0	„	„	1 5	„	„	„	„

Cephalometry is obviously most precise when the occipito-frontal diameter lies exactly transversely, i e parallel to the film in the supine position of the patient In such cases, if we measure the height of the occipito frontal diameter above the film, and the height of the tube above the film, we can employ the perforated lead sheet method of *Thoms* or the geometric principle of *Roberts*, to deduce the exact measurement of the occipito frontal diameter.

Having obtained this, the biparietal diameter can be estimated by reference to *Thoms'* table as given above

If however, the head is tilted slightly, the diameter shown on the film will not be the true occipito frontal diameter, but will be an oblique diameter

ROWDEN'S METHOD

Rowden advocates the taking of the cephalometric radiogram with the patient sitting in the same position as for pelvimetry The cephalometric and pelvimetric measurements by this means are available from the single radio gram He employs standard cephalic scale strips for the cephalometric estimations prepared in the same manner as those for pelvimetry the appro priate scale being chosen according to the height of the centre of the fœtal skull above the film (6 to 9 inches with ½ inch intervals)

WALTON S METHOD

The patient is placed in the supine position with the fœtal skull over the centre of the Potter Bucky diaphragm

(1) A mark A is made on the anterior abdominal wall over the centre of the child s head

(2) A mark L is made on the lateral abdominal wall on the side nearest to and directly opposite the centre of the child s head

(3) An antero posterior radiogram is taken centring the tube vertically above the mark A The vertical heights of the tube and of the mark ' L" above the film are measured

(4) A lateral radiogram is taken (with the film on the side next to the mark L) centring the tube horizontally opposite the mark L The horizontal distances of the tube and of the mark A from the film are measured

By applying the geometric principle illustrated in Fig 271 the true occi pito frontal and biparietal diameters of the fœtal skull can now be estimated

REECE'S METHOD

Reece concentrates on the measurement of the biparietal diameter According to his conception the fœtal skull (exclusive of the facial bones) is roughly egg shaped the long axis of the ovoid being the occipito frontal diameter and its short axis representing either the biparietal or suboccipito vertical or an intermediate diameter of what he calls the greatest circular section In any radiogram of the fœtal skull some diameter of this greatest circular section is shown from the nature of the cephalic shadow the bi parietal diameter can be estimated from the radiogram For this purpose we must know (a) the distance of the nearest point of the skull from the tube (TP), (b) the distance of the film from the tube (TF)

In order to arrive at the distance from the tube of the centre (H) of the

plane shown in the radiogram 2 inches is added to the measurement TP for all cases near term (Where instead of using the approximate estimate of 2 inches greater accuracy in the factor PH is desired this may be allowed for by a consideration of the age of the fœtus and the shape of the cephalic shadow seen on the film Such a refinement however is as a rule not called for)

Employing the principle illustrated in Fig 271 the correction factor is $\frac{TH}{TP}$ or $\frac{TP+2}{TF}$

In his technique the patient is placed in the supine position on the Potter Bucky couch the fœtal skull is carefully palpated and the tube centred over the highest point palpated (P) A constant tube film distance (in this case 30 inches) is maintained

The distance (TP) of the target of the tube from this point is measured by means of a telescopic measuring rod attached to the tube (allowance is made for the thickness of the abdominal wall) The measurement TP is recorded and the exposure made

After development the short axis (a diameter of the greatest circular section) is measured on the film

By reference to tables the biparietal diameter can be readily obtained

McDONOGH S METHOD

In *McDonogh s* method as in *Reece s* method the biparietal measurement alone is considered as from the obstetrical aspect it is of major importance the diameter of the greatest circular section which is seen in all projections irrespective of its relation to the film is here regarded as equivalent to the biparietal measurement

The technique is as follows The patient is placed on the Potter Bucky diaphragm (flat type) in the prone position if possible or failing this supine The approximate centre of the fœtal head is located by palpation and adjusted over the middle of the Potter Bucky diaphragm immobilisation being secured by the usual band in a position which will not interfere with placing a film in line with the head

A film is then placed alongside the patient on the side nearer to the fœtal head *A graduated lead rule resting vertically on the Bucky surface is* interposed between the patient and film A Lysholm grid is of assistance but is not essential

The X ray tube is positioned on the opposite side of the patient so that its central ray is projected horizontally through the mid point of the fœtal skull *the exposure made and the film removed*

A second film is placed in the Bucky diaphragm and the tube brought to the standard height vertically above the centre and a second exposure made The time interval between the two exposures should be as short as possible to avoid fœtal movement

The height of the fœtal head above the second film will be indicated by the image of the lead rule on the first Selecting from the complete set of standard scales, kept in the X ray department, that corresponding to the height indicated the biparietal diameter is measured direct from the image on the second negative

For routine work a set of standard scales is necessary, but if the number of cases is small the measurement may be obtained by using the following equation

$$CD \times \frac{tf - sf}{tf} = d$$

When CD = Greatest circular diameter of head as measured on the negative
tf = Distance from X ray tube to film
sf = Height of fœtal skull above film
d = Actual greatest circular diameter of fœtal skull
= biparietal diameter

PREPARATION OF STANDARD SCALES —Before making a set of standard scales one must decide upon the height at which the X ray tube is to be operated and this setting must be adhered to in all subsequent measurements with the particular scales

If the power available will allow a distance of 4 feet or more should be chosen but with a low powered plant 25 inches may be used successfully, though the accuracy diminishes as the distance is decreased

A rule made from sheet lead about 1 inch wide and reinforced by wood or metal strips is required One edge is marked by fine saw cuts at intervals of ¼ inch and the other at intervals of 1 cm

This rule is set above the centre of the Potter Bucky diaphragm (flat type) at a height of 3 inches and with the tube at the predetermined height, radiographed on to a section of 15 × 12 inch film, the remainder of which is protected by sheet lead The rule is then raised to 3¼ inches and radiographed on to a fresh section of film This process is continued up to a height of 10 inches Each section at the time of exposure is marked by means of lead numbers to indicate the height of the rule

The films on which the images of the lead rule have been imprinted are processed in the usual way and after washing each is squeezed between two sheets of clear celluloid and allowed to dry slowly, before cutting into strips The celluloid is used as a protection for the gelatine against moisture or abrasion A smear of 'Durofix' along their edges renders the scales water proof and allows one to measure direct from wet films without damage

DISPROPORTION

Valuable information can be obtained regarding the relative size of the fœtal head and maternal pelvis by direct radiography in the prone supine,

and lateral views *It is important to bear in mind that in supine views the* foetal head is nearer the X-ray tube than is the pelvic brim, the former will therefore be enlarged out of proportion to the latter In prone positions the converse holds Comparison of the prone and supine radiograms, supplemented by a lateral radiogram, will usually give the desired information as to the relative size of the foetal head and maternal pelvis

More precise information will, of course, be obtained by combined radiological pelvimetry and cephalometry In comparing the pelvic measurements with the cephalometric ones, however, one must bear in mind that both the maternal bony pelvis and the foetal bony vault are clothed with soft tissues (*Thoms*, by checking his results before and after delivery by Cæsarean section, *finds that 2 mm must be added to the cephalometric measurements as an* allowance for the thickness of the scalp)

The reader should be reminded that the radiological demonstration either of a normally sized pelvic brim or of a normally sized foetal head does not necessarily ensure normal delivery A large head may give rise to just as much difficulty in passing through a normally sized pelvis as a normal head will cause in the case of a contracted pelvis

In other words, to assure as great a degree of safety as is possible, both a *normal pelvic brim and a normal or small foetal skull must be demonstrated*

One is driven to repeat that while both radiological pelvimetry and cephalometry have their uses the best pelvimeter, in vertex presentations is the foetal skull Where this cannot be applied then the radiologist can give very valuable information which may save the mother's life, by indicating to the obstetrician the necessity or otherwise for Cæsarean section before obstetrical interference per vaginam has been allowed to add to the risks of such a procedure

Furthermore one must bear in mind that normal delivery may conceivably take place even where there is an apparent disproportion for the radiologist is unable to assess two unknown factors, viz the strength of the uterine contractions, and the degree of skull moulding which will take place during labour

Radiological pelvimetry, if properly performed, is a procedure of precision, *and the measurements do not normally alter to any appreciable degree as the* result of parturition Cephalometry, on the other hand, lacks this degree of precision and the measurements alter considerably during the course of normal labour

CHAPTER XXXV

THE RADIOLOGICAL ESTIMATION OF FŒTAL MATURITY

Though in many cases the clinical history is sufficiently reliable to justify a reasonably accurate estimate of maturity of the fœtus an element of doubt not

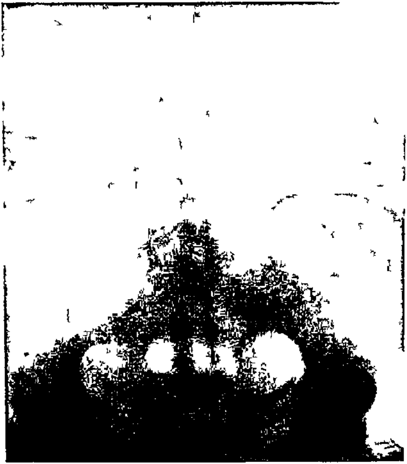


Fig. 276.—Patient in supine position: simulation of hydrocephalus by normal skull due to anterior position of head (case of twins). Compare Fig. 277 of same patient in prone position.

infrequently arises owing either to uncertainty about the date of the last menstrual period or to conception having occurred during a period of amenor

rhœa (as in lactation), or to a discrepancy occurring between the size of the gravid uterus and the clinical estimate of maturity.

FIG. 277.—Same patient as Fig. 276, patient in prone position; normal-sized skull (twins).

The radiologist, when asked to help in the assessment of the fœtal maturity, usually bases his estimation on two factors:

(i) The size of the fœtus.

(ii) The stage of ossification of the fœtal bones.

Most radiologists of experience will have formed a fairly reliable mental impression of the size of the fœtus at different periods of gestation. In doing so they will probably have observed two important rules, viz.:

(i) The maintenance of a standard distance between the X-ray tul

the film, a convenient distance being 30 inches. (Comparisons of size cannot be satisfactorily made unless a standard distance is maintained.)

(ii) The routine taking of a radiogram with the patient in the prone position. This is necessary because by adopting this position, the fœtus is brought closer to the film, and its film image is thus enlarged or distorted as little as possible.

The difference in size between the fœtal skull on a radiogram taken in the prone position and that of the same patient taken in the supine position is at times most marked (Figs. 276–277).

In estimates of age from a mere inspection of films, however, the personal element enters too largely into interpretation to allow of the method being of universal utility, and a more precise method is obviously desirable.

Such a method has for some time been in vogue in the practice of cephalometry, the measurement by means of X rays of one or other of the diameters of the fœtal skull. Up till recent times the diameter usually measured has been the occipito-frontal. If this diameter lies parallel to the film, it is a matter of ease to measure its exact length from the radiogram either by the grid method of *Thoms* or by the geometric principle of *Walton*.

Obviously, in this method the fœtal head must be orientated with precision, for any appreciable degree of obliquity of the occipito-frontal diameter (except in the method of *Thoms*) will render the attempt to estimate this diameter difficult or even impracticable.

According to Scammon and Calkins the occipito-frontal diameter bears a definite relation to the age of the fœtus. The following table has been abstracted from their chart.

Age of Fœtus in Calendar Months	Occipito-frontal Diameter
End of third month	2.8 cm.
fourth	4.8
fifth	5.6
sixth	8.2
seventh	9.7
eighth	10.9
ninth	12.2

By examination of a large number of fœtal skulls at different stages of maturity, however, *Scammon* and *Calkins* find that considerable individual variations may occur (Fig. 278). It is obvious that whilst a certain length of the occipito-frontal diameter may *on the average* correspond to a certain period of gestation, an estimate of maturity based on such measurements may, in any individual case, *be as much as three or four weeks out of reckoning.*

REECE'S METHOD OF ESTIMATING MATURITY

The biparietal diameter of the fœtal skull is estimated by the method described on page 402.

On the assumption that the biparietal diameter increases by $\frac{1}{10}$ inch per week during the last few weeks of pregnancy to attain a measurement of 3 75 inches at full term, *Reece* estimates the number of weeks from full term which the fœtus has reached, he claims a considerable degree of accuracy in his results

ROBERTS METHOD OF ESTIMATION OF MATURITY

If the presentation be a vertex the patient is placed in the prone position *with a 12 × 10 inch cassette beneath the hypogastrium, the Potter Bucky* diaphragm not being used She is postured so that the hypogastrium is as *nearly as possible in con*tact with the cassette

The tube is centred 4 feet vertically above the cassette and a radiogram is taken Though not of the same quality as a Potter Bucky radiogram the fœtal skull is shown *with sufficient clarity to* allow of its suboccipito bregmatic diameter being measured on the film Provided the skull is normal in size and the hypogastrium is touching the cassette the suboccipito bregmatic diameter in inches multiplied by ten gives approximately the number of weeks of maturity This applies only to a patient of average build whose hypogastrium has been brought into actual contact with the *cassette If the patient be fat or if her hypogastrium* cannot be brought into contact with the cassette or if a lateral view shows the position of the head to be *occipito posterior*, a week, or in extreme cases two weeks, should be deducted from the maturity computed as above

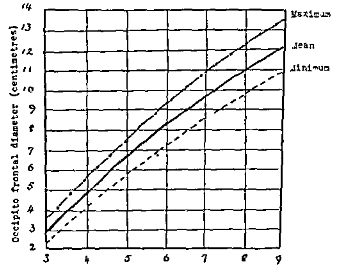


FIG 278 —Variation of occipito frontal diameter with age of fœtus (*From Scammon and Calkins*)

(The method is based on the principle that under the conditions described a true suboccipito bregmatic diameter of 3 75 inches becomes a film diameter of 4 inches due allowance being made for the estimated distance from the film, in an average case, of this diameter)

It should be emphasised that *Roberts'* method of estimating maturity here described is only applicable (*a*) during the last two months of pregnancy, and (*b*) in vertex *presentations*, where, in the prone position of the patient, the

fœtal skull is close to the cassette In breech presentations an element of uncertainty is introduced by the variable height of the fœtal head The chief merit of this direct or non Bucky method lies in its simplicity

Limitations of Cephalometric Methods of Estimating Maturity—Cephalometric methods of estimation of maturity would be of greater reliability if all fœtuses when delivered were of a standard size but as a full term fœtus may vary in weight from 4 lb to 9 lb it is unreasonable to expect all of them to have biparietal diameters of a standard size

Whilst *on the average* the radiological estimates of maturity are found to be fairly accurate individual cases occur in which the discrepancy on either side may be as much as three weeks Because of this variation from the average which may occur in any individual case no cephalometric method of estimating maturity can be regarded as universally reliable In any case of clinical doubt as to maturity such methods are however justifiable as being the only alternative means at our disposal But it must be realised that they are not infallible in their results

ESTIMATION OF MATURITY FROM OSSIFIC CENTRES

Apart from the general size and cephalometric measurements there is another point needing brief consideration namely the stage of ossification of the bones The radiologist develops a general idea of their X ray appearances and degree of calcification from thirteen weeks (when they are first demonstrable) to full term and beyond that to post maturity There are however certain ossific centres which make their appearance during the later months of pregnancy which have been regarded as of special importance These are the ossific centres for the lower epiphysis of femur the upper epiphysis of the tibia the os calcis astragalus and cuboid

The average dates of appearance of these centres are as follows

Os calcis	21st to 29th week
Astragalus	4th to 32nd week
Cuboid	40th week
Lower epiphysis of femur	35th to 40th week
Upper epiphysis of tibia	40th week

Unfortunately however these are merely *averages* and in any individual case considerable variations may occur For instance one has occasionally encountered a fœtus of thirty-seven weeks in whom both the femoral and tibial epiphyseal centres were very well developed and clearly visible on the radiogram or a fœtus of forty weeks in whom neither was present being completely absent on good radiograms showing clearly the fœtal knee joint

POST-MATURITY

In cases where the patient is suspected of having gone beyond the computed ... n the radiologist may be called upon to decide whether the

fœtus is post-mature or not In post maturity he will find a large but well-ossified cranial vault, well defined but not large fontanelles, massive and well-ossified limb bones, frequently large and well developed ossific centres for the lower end of the femur and upper end of the tibia, and well developed ossific centres for the os calcis, astragalus, and cuboid

The differential diagnosis between the large and well-ossified head of the post-mature fœtus and the large head of the hydrocephalic fœtus with comparatively thin cranial bones and wide fontanelles is referred to later

MEDICO-LEGAL ASPECTS

In cases of suspected criminal abortion the radiologist may be called upon to examine the charred remains of the fœtus in order to decide whether the fœtus was viable or not at the time of its destruction It is therefore important to know what ossific centres are normally present in a fœtus of twenty-eight weeks' gestation, and more particularly those which appear after this

The ossific centres which appear between the twenty eighth and fortieth week are the following (*Holmes* and *Ruggles*)

Hyoid bone greater cornu	29th to 32nd week
Coccyx	*37th to 40th week*
Lower epiphysis of femur	35th to 40th week
Upper epiphysis of tibia	40th week
Astragalus	*24th to 32nd week*
Cuboid	40th week
Middle phalanx fourth toe	29th to 32nd week
Middle phalanx fifth toe	*33rd to 36th week*

Radiographic demonstration of air in the lungs or stomach of a dead child is of value in deciding whether or not the child lived after birth (*Haykis*)

CHAPTER XXXVI

THE FŒTUS POSITION PRESENTATION AND ABNORMALITIES

POSITION AND PRESENTATION

WITH RADIOGRAMS in two planes (supine or prone and lateral) the position of the fœtus is readily demonstrated and we can say whether the occiput or sacrum is to the left or to the right and anterior or posterior

FIG. 279—Brow presentation extension of head but no spinal deformity (cf Fig. [illegible])

FIG 280 —Breech with legs flexed

Similarly the presentation—vertex, brow, shoulder, transverse, breech, etc —is clearly shown

Furthermore, valuable information is available as to the degree of flexion or extension of the head (Fig 279) the position of the lower limbs (whether flexed or extended in breech cases (Figs 280, 281 282) a matter of great importance in influencing the success of version) and the position of the hands in relation to the fœtal head

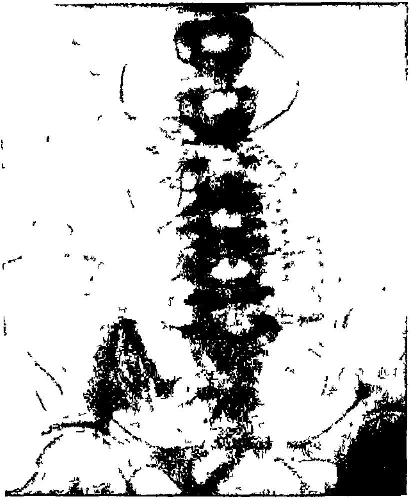


Fig. 81. Breech with legs extended

With a motile fœtus, however, it is sometimes disconcerting to note the sudden changes in position which may occur even at the seventh month or so. On one occasion in the author's experience complete version of a breech presentation was spontaneously performed during the brief interval which elapsed during the turning over of the patient from the supine to the prone position. At any stage prior to the middle of the ninth month the radiologist should therefore be careful to state in his report that "at the time of the examination" the position and presentation were "so and so."

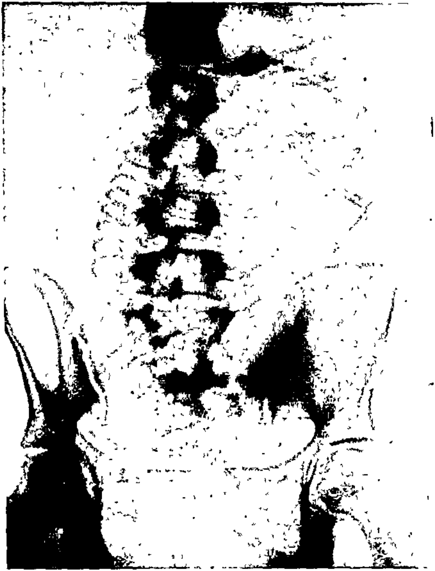


Fig 282.—Full-term fœtus Breech with extended legs Well developed femoral and tibial epiphyseal ossific centres

MULTIPLE PREGNANCY

One cannot help being impressed by the frequency with which, in cases of hydramnios, twins are demonstrated radiologically where no opinion as to their presence has been formed clinically, and alternatively the frequency with which a multiple pregnancy has been proved radiologically to be absent when a

Fig 283 —Twins foregoing vertex aftercoming breech

tentative diagnosis of such has been made clinically In this respect the radiographic evidence is usually beyond question (Figs 283, 284) It should be emphasised, however, that the exclusion of the possibility of multiple pregnancy should be made only after at least two satisfactory radiograms have been taken Every radiologist of experience will be able to recall cases in

one radiogram, but, because of a burst of

Fig 284.—Twins Both breech

fœtal motility on another radiogram of the same patient no signs of the fœtus were visible This might quite feasibly happen to one of a pair of twins

Triplets are occasionally seen (Fig 285)

When reporting the radiologist should give details as to the position and presentation of each fœtus shown with special reference to the *forecoming fœtus*

Fig 8 —Trip l s (lat ral v w of ut ru)

EXTRAUTERINE PREGNANCY

If in the radiogram part or whole of the fœtus can be seen to lie outside the uterine shadow the radiological diagnosis of extrauterine pregnancy can be made with certainty

Extrauterine pregnancy may sometimes be suspected from an unusually high or abnormal position of the fœtus In such cases however a most careful collaboration between the radiologist and the obstetrician is of paramount importance Pneumoperitoneal radiography will give valuable information *radiography after the introduction of a rubber tube into the uterine cavity (if* considered justifiable) may lead to error in the presence of a bicornuate uterus Radiography after the introduction of lipiodol into the uterine cavity may reveal a normally shaped or elongated uterus in ectopic pregnancy this method however is not justifiable except in confirmation of the strongest clinical or radiographic suspicion of extrauterine pregnancy and where a termination of the pregnancy in any event is desirable

FŒTAL ANOMALIES AND ABNORMALITIES

On many occasions when hydramnios has been present and when the obstetrician has been in doubt as to its cause the revelation of a gross fœtal abnormality by radiography has made the diagnosis clear

In the antenatal demonstration of fœtal abnormalities radiology plays a part of the greatest importance for precise knowledge of their presence and presentations may by forewarning the obstetrician not only save him from considerable embarrassment at delivery but may empower him to concentrate boldly on measures which aim at the saving of the mother s life regardless of that of the fœtus

The common abnormalities of this type which may be shown by X rays are the following

Hydrocephalus —The frankly hydrocephalic skull is readily demonstrated radiologically (Fig 286) The large size of the fœtal skull in relation to its body and to the size of the maternal pelvis usually establishes the diagnosis beyond doubt At full term it is sometimes difficult to differentiate between *a mild degree of hydrocephalus and the large skull of post maturity (Fig 287)* In the latter however the thick and well calcified cranial bones the normally sized fontanelles and the size and advanced degree of ossification of the limb bones combined with the clinical history will usually settle the diagnosis Occasionally it is very difficult to decide precisely from the radiograms whether a mild degree of hydrocephalus is present or not

The recent work of Walsh who after definitely establishing a diagnosis of a hydrocephalic vertex presentation by radiography has perforated the enlarged fœtal skull per abdomen so that the head thus reduced in size might pass

through the maternal passages without difficulty, is of interest (Figs 288 289)

Anencephaly—Whilst a diagnosis of anencephaly may often be made on clinical evidence alone cases are occasionally encountered in which this

Fig 289 Hydrocephaly Note the cranial bones and wide fontanelles

abnormality (associated with hydramnios) has been clinically mistaken for a breech presentation with no suspicion as to anencephaly

The radiographic appearances showing the absence of the rounded cranial vault are characteristic (Fig 290) Occasionally an additional abnormality such as spina bifida is seen on the radiogram (Fig 291)

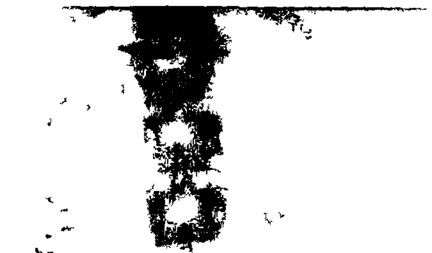


Fig 287 —Post mature fœtus Note thick cranial bones and well developed limb bones Femoral centres clearly visible

In demonstrating this condition radiograms should be taken in such position as will throw the shadow of the fœtal skull clear of the maternal skeleton The lateral view is often of value in such cases

Iniencephaly —This is a condition associated with an imperfect formation of the *occiput in the region of the foramen magnum spina bifida (often of* considerable extent) and retroflexion of the cervical spine (*Ballantyne*)

FIG. 288.—Hydrocephalus before tapping by puncture of skull.

Fig. 289.—Hydrocephalus after tapping by puncture of skull. Easy delivery ensued

Fi 900 I st matur a nerj hal fa t s N te large f moral an I t b al oss fic ent tre

Fig. 291.—Lateral view of uterus. Anencephaly and spina bifida.

Fig. [illegible].—Iniencephaly. Brow presentation with well marked angular spinal deformity due to spina bifida.

Sometimes the skin and tissues clothing the skull pass directly from the back of the vertex on to the back of the thorax of the fœtus without any intervening suboccipital depression.

Care must be taken in reading the radiogram not to mistake for iniencephaly a simple hyperextension of the head and it must also be

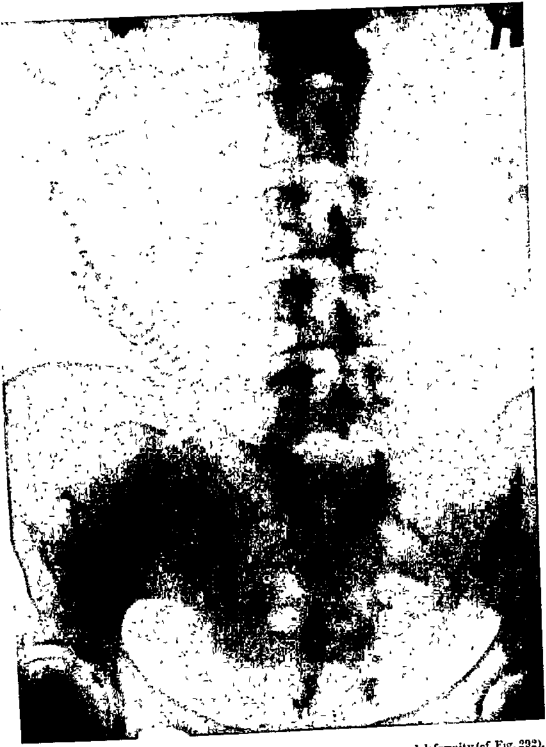


FIG. 293.—Fœtal thyroid tumour. Note hyperextended head but no spinal deformity (cf. Fig. 292).

Fig. 291 An encephalic foetus with well marked ... (spina bifida) in lower dorsal re...

remembered that hyperextension of the cervical spine may be caused by thyroid tumours

In anencephaly the diagnostic radiological feature is the demonstration in a foetus whose head is hyperextended of an abnormality of the cervical spine or occiput *Fig 292 shows such a condition in which this combination is* clearly shown

Thyroid Tumour Where this is present in the foetus (Fig 293) the head is hyperextended but there is no abnormality of the cervical spine as seen in

niencephaly The antenatal diagnosis of such a lesion cannot be made by direct radiography alone Amniography in a suspected case may be helpful

Spina Bifida —In any radiogram where the normal spinal curve of the fœtus

Fig 295 —Meningocele High position of fœtus Abnormality of occipital bone noted

is seen to be altered the possibility of spina bifida should be considered In such cases radiograms should be taken *in different positions so as to bring the fœtal spine into profile* i e to produce a direct lateral view of the fœtal spine

In spina bifida there is seen to be an alteration in the normal spinal curves,

together with a defect in the formation of the spinous processes in the affected area (Fig 294)

Meningocele—Though the sac of a meningocele cannot be differentiated from the liquor amnii by direct radiograms, the possibility of such a lesion should be borne in mind in any case where a defect or an abnormal shape of the skull bones is shown, or where there is a suspicion of spina bifida Fig 295

Fig 296—Meningocele fœtus after delivery (Same case as Fig 295)

shows a case in which an abnormality of the occipital bone was observed in the antenatal radiogram together with a high position of the fœtus, while a soft sac could be palpated per vaginam The patient went into normal labour the same day Fig 296 shows the fœtus after delivery

Rudimentary Limbs—A satisfactory series of radiograms should show all the fœtal limbs *in detail* *Any abnormality should be reported*

Fig 297 shows a case in which rudimentary fœtal arms were diagnosed before birth Fig 298 shows this fœtus after delivery The additional diagnosis of intrauterine death in this case was also made antepartum This was made possible only after two radiographic examinations at a week's interval had been made *and the fœtus was seen to have failed to increase in size in* the interval *Spalding's sign* (see later) was only doubtfully positive

Fig 298 —Intrauterine death and rudimentary upper limbs (diagnosed before delivery)

INTRAUTERINE DEATH

The most reliable sign of intrauterine fœtal death is that described by *Spalding* viz an overriding of the cranial bones This is due to shrinking of the brain with consequent falling in of the vault and may be found within four to seven days of intrauterine death (*Matthews*) (Figs 299 300 301)

Care must be taken not to confuse the overriding or moulding of fœtal death with that which normally takes place during engagement of the head or more markedly during labour (Fig 302) Very rarely overriding may be seen

where there is neither intrauterine death nor where the patient is in labour, possibly such cases may be associated with scanty liquor amnii

Spalding's sign of overriding seen at a single radiographic examination can

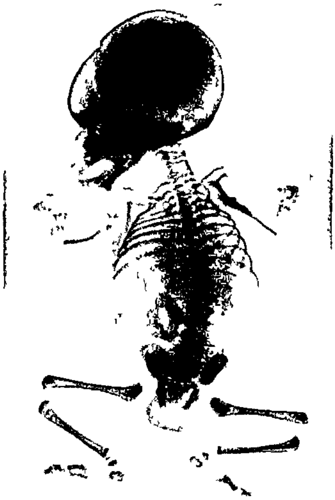


Fig. 218. Fœtus of Fig. 217 after delivery. Note rudimentary upper limbs. Ossific centres for os calcis and astragalus well developed

therefore only be regarded as strong *presumptive* evidence of intrauterine death and must be carefully correlated with the clinical evidence

Other radiographic signs of intrauterine death have been described these are

(1) *Lordosis of the lumbosacral fœtal spine (Junjman)* This sign is of little value and often cannot be seen unless the fœtal spine is shown exactly in

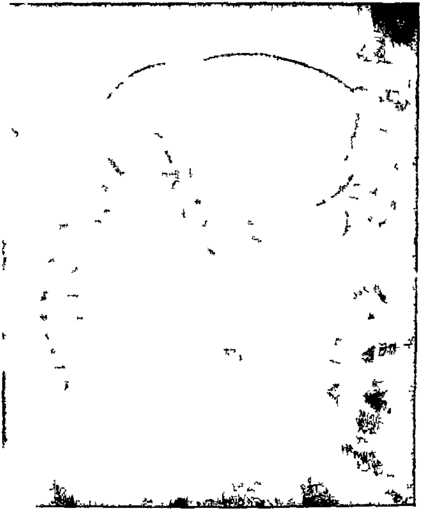
Fig 299—Intra uterine death overlapping of cranial bones (Spalding's sign)

profile an obliquity of position of the fœtus may mask it and it may be present in the case of living twins

(2) Falling in of the thorax (of very doubtful significance) or marked kyphosis of the dorsolumbar spine

(3) Osteoporosis of the fœtal bones This is more likely to be due to a faulty metabolism of the mother or it may be simulated by the use of too penetrating a ray

(4) A fœtus which is much too small for the period of amenorrhœa The fœtal maturity can be estimated by the method described earlier If this be found to fall short of the clinical estimate by a month or more a suspicion of



F 300 Breech 1 tra erine l atl (Spald) s g 1 os t)

fœtal death is raised but it must of course be remembered that the menstrual history is not always reliable

It must be emphasised that an absence of overlapping of the cranial bones does not necessarily imply a living fœtus In 50 per cent of the cases of intrauterine death radiographed by the author no overlapping was visible at the first radiographic examination In any cases of clinical or radiological

doubt, therefore radiograms should be taken periodically (say at weekly intervals) till it can be definitely decided that *Spalding's* sign is positive or that the fœtus is neither growing nor moving A lowering of the level of the

Fig 301 Intra-uterine death (*Spalding's sign positive*)

fundus of the uterus or an increase in the spinal curve of the fœtus shown after an interval is also strong presumptive evidence of fœtal death

It will of course be appreciated that X ray *evidence in such cases will* necessarily be complementary to the clinical evidence a close collaboration between the radiologist and the obstetrician is imperative if mistakes are to be avoided

CHAPTER XXXVII

PLACENTA PRÆVIA

IN A case of antepartum hæmorrhage it is of the greatest importance to the clinician that he should be able to ascertain whether this bleeding is of the nature of an ' accidental hæmorrhage " due to a detachment of a normally placed placenta or whether it is due to the more serious complication of placenta prævia

If the cervix be sufficiently dilated, either through labour having started or through the hæmorrhage having been profuse, the clinician may be able by means of the palpating finger to decide whether the placenta is encroaching on the os uteri If the cervix is closed, however, this is not possible and the help of the radiologist may be invited in an effort to decide whether the placenta is normally placed or whether it is partially or wholly implanted on the lower uterine segment

DIRECT RADIOGRAPHY

Snow and *Powell* claim that by a careful inspection of good films of the gravid uterus they can pick out the placenta as a half shadow between the boundary of the uterus and the fœtal parts but they include no cases of placenta prævia in their series

Attempts have also been made by *Staveley* to diagnose the position of the placenta from an examination of radiograms of the gravid uterus, in which there were sometimes shown groups of shadows which were thought might be due to phleboliths or calcified patches in the placenta By a radiographic examination of a number of such cases before and after parturition, together with the placenta after extrusion I have convinced myself that such calcifications are as a rule not in the placenta, but in mesenteric glands which have been displaced by the gravid uterus To base an opinion as to the placental site from the presence of such calcified patches is therefore liable to lead to error as there is no means by which one can be certain whether such calcifications are in the placenta or in the glands

AMNIOGRAPHY

(Radiography after injection of opaque fluid into the amniotic sac)

Menees, Miller and *Holly* by the *injection of strontium iodide into the* amniotic sac in pregnant women found that this substance, mixing with the

liquor amnii and being opaque to X rays gave a satisfactory amniogram i e a radiographic shadow representing the amniotic cavity The fœtal parts and the placenta were seen as more translucent areas in the more opaque liquor amnii

FIG 30 —Moulding of skull during labour (not to be confused with *Spalding's* sign of intrauterine death)

The placenta if disposed edge-on to the incident X ray beam therefore showed as a filling defect on the edge of the amniotic sac and its site could thus be ascertained They recorded no ill-effects either to mother or child

Munro Kerr and *Mackay* in adopting this method found that in some of their cases the injection of strontium iodide into the amniotic sac resulted in the death of the fœtus *They therefore substituted Uro electan B for strontium iodide In a series of ten cases they obtained good results with no fœtal*

fatalities They found however that even this non toxic and non irritant medium tended to terminate pregnancy

Technique —The injection is made at a site chosen in the lower half of the abdomen where it is least likely to damage the fœtus, i e over the site of the fœtal limbs the maternal skin having been previously sterilised and anæsthetised

When the point of the needle is felt to have entered the amniotic cavity, 20 70 c c of amniotic fluid is withdrawn (this is not always essential) and 20-50 c c of Uroselectan B is then injected slowly an occasional slight withdrawal of fluid being made at intervals during the injection to make sure that the point of the needle is still free in the amniotic cavity The method should not be employed if there is present a scar of an abdominal incision as there may then be a risk of puncturing adherent gut

During the next half hour mixing of the drug *with the amniotic fluid* is encouraged by placing the patient in different positions every few minutes A *series of radiograms is then taken* (on 17 × 14 *inch films*) in different planes—antero posterior lateral and oblique—so that in one or other of them the placenta is end-on and a corresponding filling-defect can be made out on the radiograms The differential diagnosis between accidental hæmorrhage and placenta prævia is thus made possible by the visualisation of the placental filling defect in the upper or the lower part of the uterus (Figs 303, 304)

The diagnosis is *sometimes* rendered difficult by the *appearance* of pseudo filling defects on the boundary of the uterine shadow due either to the pres *sure of translucent gas filled bowel or of surrounding structures or to the* presence of a large blood clot between the wall of the uterus and the bag of membranes Other less likely sources of error might be the presence of a fibroid or the existence of multiple pregnancy

Kerr and *Mackay* found that as a result of the injection of Uroselectan B, labour was brought on after an interval varying from a few hours to five days For this reason the method should be restricted to the later weeks of pregnancy In course of time no doubt some substance will be discovered which is still less irritant than Uroselectan B and which will not cause an induction of labour

Burke reports a series of seventeen cases in whom he performed amnio graphy with *Uroselectan B In twelve cases in which large (17 × 14 inch)* films were used the position of the placenta was accurately diagnosed by this method *In four cases the examination was spoilt by the use of smaller* (15 × 12 inch) films He therefore stresses the desirability of using the larger sized film

He points out that the diagnosis of the site of the placenta is difficult only if the placenta is implanted in the upper part of the uterus where the shape of the uterine fundus is inconstant and where intestinal gas may produce

Fig. 303.—Amniogram showing:—Lateral placenta prævia in case of antepartum hæmorrhage (placenta showing as filling-defect in wall of uterus marked by dotted line). Confirmed by intra-uterine palpation after delivery of fœtus. *(Note shadow of Uroselectan in amniotic cavity and also in stomach and intestines of fœtus.)*

Fig 301 Amniogram showing lateral placenta praevia in a case of antepartum hæmorrhage (oblique view) Placental filling defect seen to be intermediate in density between the Uroselectan in the amniotic cavity and the extrauterine gaseous translucencies (Note Uroselectan in fœtal stomach and intestines)

pseudo filling defects In his series the radiological diagnosis was accurate in all cases of placenta prævia investigated

In the later weeks of pregnancy he regards the inevitable induction of labour which results from the injection of Uroselectan B as being relatively unimportant he even goes so far as to advise the use of this injection method

FIG 305 —Low placenta prævia Note wide gap between fœtal skull and fundus of bladder

in suitable cases with the deliberate aim of inducing labour as being safer than the usual methods

In thirty five cases where Uroselectan B was injected there was one instance in which death of the fœtus occurred which could not be explained by natural causes

If the amount of liquor amnii is excessive the drug may be so diluted that the shadows obtained are too faint for precise diagnosis if the liquor is scanty uterine puncture may be unsuccessful

Burke summarises the indications for amniography by stating that if in a doubtful case of placenta prævia the history of the case the physical signs and other important considerations—e g age of the patient parity, desire for a live child etc —are sufficient to indicate that Cæsarean section is considered as a possible mode of delivery then amniography should be performed But if it is decided that delivery shall be *per vias naturales* in any case then there is little

FIG 306 — A case of antepartum hæmorrhage Increased gap between fœtal skull and fundus of bladder due to a central clot (See Fig 307)

or nothing to be gained by subjecting the patient to the examination The main value of amniography appears to be as a deciding factor for or against delivery by Cæsarean section If the diagnosis proves to be one of central placenta prævia then Cæsarean section can be undertaken, with beneficial results to the child and in full confidence that the mother is not being exposed to unnecessary risk If lateral placenta prævia is diagnosed natural delivery can be awaited without undue apprehension for the safety of the mother or the child

CYSTOGRAPHY

Ude Weum and *Urner* made a preliminary report of a method by which they successfully diagnosed the presence of placenta prævia. The method consists of an injection into the bladder *per urethram* of a $12\frac{1}{2}$ per cent. solution of sodium iodide (which is radio-opaque). Normally in the later weeks of pregnancy the anterior portion of the thin walled lower uterine segment lies

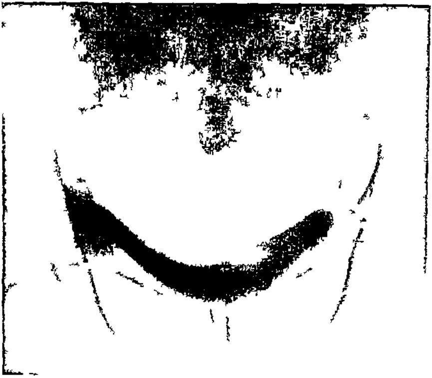


FIG. 307.—Same case as Fig. 306 two weeks later. The central clot has been absorbed or passed and the fœtal skull and fundus of bladder now show a normal relationship.

in close apposition to the postero superior margin of the bladder, separated from it only by the reflection of the peritoneum. If, therefore, the fœtal head lies in the lower uterine segment, the gap separating it from the fundus of the bladder in a supine radiogram should be narrow, whilst if there be a placenta prævia interposed between them the gap should be widened according to the degree of interposition (Fig. 305). The method therefore presupposes a vertex presentation and is not applicable to a breech or a transverse lie. Moreover the gap will be greater in the case of a central placenta prævia than in a partial placenta prævia, depending on the differing thickness of placenta intervening.

A drawback of the method lies in the fact that a central blood clot will give the same cystographic appearances as a central placenta prævia (Figs 306 307) Furthermore the method is only applicable to vertex presentations in the latter weeks of pregnancy in the earlier stages of pregnancy there may normally be a wide gap between the fœtal head and the fundus of the bladder

The method is of maximum utility in the case of central placenta prævia (provided the presence of a central clot can be excluded) In cases of lateral or marginal placenta prævia the accuracy of the radiological diagnosis by this method is often in doubt

Instead of injecting a radio opaque solution of sodium iodide into the bladder *per urethram* the oral administration of sodium ortho iodo hippurate (Iodorax Martindale) will give good cystographic results but we have no experience of this method Similarly of course Uroselectan B injected intravenously can be used but the injection *per urethram* of sodium iodide commends itself because of its simplicity and because of the more certain control of the amount in the bladder

DANGER TO MOTHER OR FŒTUS FROM OBSTETRICAL RADIOGRAPHY

Misconception on this point has arisen from a lack of appreciation by obstetricians and others of the difference between the dosage administered in deep X ray therapy for pelvic carcinoma menorrhagia etc (where intensive or prolonged doses of penetrating X rays are given with destructive aims) and the comparatively small dosage received in diagnostic X ray examinations

The intensive dosage used in deep X ray therapy of the pelvic organs has on occasion been responsible for the causation of fœtal developmental abnormalities (*Findley Bailey* and *Hogg Murphy*) It can however be definitely stated that there is no evidence that *diagnostic* antenatal exposure is in any way harmful to the fœtus or the mother It is of course advisable to avoid any unnecessary repetition of radiographic examinations four or five diagnostic exposures however may be made at one session and repeated at intervals of one month if necessary without any risk of damage either to mother or fœtus

Goldstein and *Murphy* after an exhaustive review of the literature on the subject conclude that there is no evidence that diagnostic pelvic radiation during pregnancy is deleterious in any way to the health of the subsequent offspring

Therapeutic X rays should not be given to the pelvis if pregnancy is known to have occurred and if pregnancy occurs during the course of such treatment, the pregnancy should at once be terminated

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